UNIVERSITY OF ILLINOIS COLLEGE OF AGRICULTURE COOPERATIVE EXTENSION SERVICE CIRCULAR 1012

ILLINOIS AGRONOMY HANDBOOK 1970

The Cover. This complex setup is typical of the highly sophisticated basic research conducted by agronomists to backstop the applied research on which the suggestions in this handbook are based. In this experiment, apparent net assimilation (accumulation of dry weight of soybeans) is being measured in a controlled environment. This apparatus can be used to study the effects of leaf angle, light intensity, carbon dioxide enrichment, air pollutants, moisture stress, fertility treatments, insect feeding, or diseases on soybean growth.

CONTENTS

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THE 1969 CROP-GROWING YEAR

The year 1969 was one of contrasts in Illinois. Some farmers had the best corn, soybeans, and wheat in history. For others it was a year of frustration: a wet, cold, late planting season; young crops flooded out; problems in weed control; sprouted wheat caused by wet weather; no chance to apply fertilizer until corn was tasseled; or dry weather from mid-season to late season. State average yields for all crops were good, though not record-breaking. This is no comfort to some individual farmers who suffered near catastrophe in crops because of unusual weather.

November 10 preliminary yield estimates for 1969 by the Crop Reporting Service compared to final estimates in 1967 and 1968 were:

	1967	*1968*	*1969*
Corn (bu.)	100	89	97
Soybeans (bu.)	31	31.5	32.5
Wheat (bu.)	39	36	37.5
Oats (bu.)	58	66	62
Hay (tons)	2.70	2.73	2.70

Plowing for corn and soybeans was well ahead of all recent years in the fall of 1968 but fell behind during a wet April in 1969. There was no really early planting in 1969, yet the date of planting of major crops was near average. May was warmer than normal, but June was generally cool and wet, resulting in slow growth by all crops.

July had very favorable temperatures but was too wet in many areas. It was the third wettest July for the state since 1900. Only east central counties were dry. August, like July, was favorable for rapid growth, especially in northern Illinois where temperatures for the last half were 6 degrees above average. By early September corn and soybeans had made up for slow growth in June and were near average in maturity. August was dry in nearly all areas. Some areas received no measurable rainfall.

In late August yellowing of corn, indicating nitrogen shortage, appeared in most areas that had received heavy rainfall in June or July.

At least 100,000 acres of corn and soybeans were lost in river bottoms of the Pecatonica River in northern Illinois, the Rock and others in northwestern Illinois, and the Mississippi from Rock Island-Moline all the way to 100 miles south of St. Louis. Some of the flooding was from water that accumulated behind levees rather than from stream overflow.

The flooding was late and farmers were looking frantically for planting suggestions in mid-July in northern counties and up to August 1 in southwestern and southern counties. Many farmers shifted to early corn hybrids, early soybean varieties and even buckwheat. But thousands of acres were abandoned for 1969.

In southern and southwestern counties wet weather that caused late planting or flooding of corn and soybeans also resulted in lodged and sprouted wheat.

Wetness delayed cultivation and timely herbicide application in many fields. Preemergence herbicides were extremely helpful in many areas on both corn and soybeans. Although isolated areas of crop injury from herbicides were reported, problems were less than in recent years.

CORN

The 1969 Season

Corn planting began later than in most recent years because there were very few dry fields in mid- to late April. Planting proceeded rapidly in early May and was completed about the average date, except for parts of western and southeastern Illinois where much corn was planted in June.

Preplant application of fertilizer was below average for N, P, and K, but more nitrogen was sidedressed than ever before.

Corn emerged well and stands were generally good. Prolonged wet, cool weather in mid-May slowed growth and brought many calls about stunted, reddish purple plants. The trouble was usually seedling disease or anhydrous ammonia injury, while root-feeding insects were the cause in some fields.

Corn did not grow well in June. It was too wet in many areas and cool everywhere. Because of wetness, weeds got out of hand in many fields. Some farmers applied herbicides when corn was large and some fields had high levels of stalk breakage following heavy windstorms.

Hundreds, perhaps thousands, of farmers were unable to sidedress nitrogen as planned and asked about application at tassel time with airplanes or high-clearance equipment. They were encouraged to make such application.

A locally severe army worm outbreak occurred about the time of silking or slightly later. Preemergence herbicides were very effective in 1969. More than the usual number of calls were received about late application of herbicide where early cultivation or spraying was impossible. Several fields that were sprayed late in a few counties suffered severe stalk breakage when high winds came within a few days after spraying. The use of combinations of herbicides increased.

About mid-August nitrogen deficiency symptoms were more widespread than in any recent year because of leaching and denitrification losses in areas with high rainfall. In east central Illinois nitrogen deficiency was accentuated by dry weather.

Corn grew rapidly in July and August as a result of very favorable temperatures, warm but not hot. July rainfall was adequate in most areas and excessive in some. August was dry almost everywhere and this hurt the crop in east central and perhaps in northwestern counties.

Reports of small ears with open tips like those in 1968 began in late August. The weather was entirely different in the two years. Dry weather, combined with high population, appears to be the cause in 1969, whereas cloudy weather at the time of kernel set was believed to be the cause in 1968. In 1968 the crop prospects declined sharply after August 10, but in 1969 the November estimate was two bushels above that for August.

Yield prospects were best in an arc around the dry area in east central Illinois where rainfall was adequate but not excessive.

Soil Temperature as a Guide to Corn-Planting Time

Each year more Illinois farmers are asking how early they should start planting corn. University of Illinois agronomists suggest that a combination of date and soil temperature is the best guide. If the temperature is high enough, start planting anytime after April 1 in southern Illinois, April 10 to 15 in central Illinois, and April 20 to 25 in northern Illinois. It would likely be unwise to plant your entire acreage on these early dates.

Corn will hardly germinate at all at 50° F. and only slowly at 55°. When the soil is at a good moisture content for planting the soil temperature will rise very rapidly on a clear day, even at a depth of 4 inches. At 8:00 a.m. April 15, 1968, the soil temperature was 43° at both 2 inches and 4 inches. At 11:30 a.m. (3½ hours later) with bright sunshine the temperature had climbed to 60° at 2 inches, a 17° increase. The time when you take the temperature is, therefore, important.

Here are two useful guides, though they may not be correct all the time.

1. Plant when the temperature at *7:00 a.m. reaches 50° F. at the 2-inch level.* This will assure a temperature favorable for growth during most of a 24-hour period if there is an appreciable amount of sunshine.

2. Plant when the temperature at *1:00 p.m. reaches 55° F. at the 4-inch level.* The 4-inch level is suggested for the 1:00 p.m. measurement because this level is not affected as much as the 2-inch level by a single day of bright sunshine. After May 1 in central Illinois and May 10 in northern counties, *plant if the soil is dry enough even though temperature is below* the suggested guidelines. Perhaps a simple way to say it is: early in the season plant according to soil temperature; later on plant by the calendar.

Incidentally, soil temperature data put out by the weather bureau are taken under sod where the midday temperature at 2 to 4 inches is often 8 to 12 degrees lower than under bare ground.

What happens if you plant early and young corn is frosted? It seldom is seriously affected because the growing point is below ground. Only the leaves that are ultimately the lowest leaves (base of the stalk) are killed. They normally don't function very long anyway because they soon slough off and new higher leaves take over the job of photosynthesis. Four- to 6-inch tall early planted corn that has the leaves frozen, but is not killed, will likely yield as well as or better than corn planted ten days later and not frosted. The worst that can happen is to lose the stand and have to replant at a cost of $8 to $10 per acre. It is best to have an early, high-yielding crop that can be harvested extra early in fall.

Many people underestimate the probability that it will rain and there will be an unintentional delay of 2 to 4 weeks if planting is delayed after soil temperature and moisture are right. Agronomists feel that it is a good gamble to start planting a week to ten days before the average best date.

Metal probe thermometers are available for about $10 from:

Weston Instruments
Newark 12, New Jersey 07114

Taylor Instrument Companies
Consumer Products Division
Asheville, North Carolina 28801

Great Northern Equipment Company
236 E. Union Street
Springfield, Illinois 62702

A 13-inch wooden thermometer with glass tube is available at less than $2 from:

Ohio Thermometer
33 Walnut Street
Springfield, Ohio 45505

Heat Units and Corn Development

Temperature records can be used to predict the maturity development of corn. The greater the amount of solar energy received, the more rapid the development of corn toward maturity. Corn hybrids of differing maturities require differing amounts of solar energy to reach maturity.

The "heat unit" is used to describe and record the solar energy received. Heat units for corn are calculated from the maximum and minimum temperatures of the day. Temperatures above 90° F. are recorded as 90° F. Temperatures below 50° F. are recorded as 50° F. Growth of corn stops as temperatures are lower than 50° F. Net growth is about zero as temperatures exceed 90° F.

The formula for determining the number of heat units is:

$$\frac{\text{Maximum daily temperature} + \text{Minimum daily temperature}}{2} - 50 = \text{Heat units}$$

Heat-unit measurements begin May 1 and end October 1 in central Illinois.

A 125- to 130-day-maturity hybrid requires about 2,800 heat units to reach maturity. In 1965 this amount of heat units was received in 130 days from planting, but in 1967 it required 147 days from the same planting date. Maturity ratings of hybrids are based on an average of years.

The following figures show the accumulated heat units for corn at Urbana on the first of the month from June 1 to Oct. 1, 1966 to 1969:

	1967	*1968*	*1969*
June 1	297	315	485
July 1	996	989	1,057
Aug. 1	1,694	1,746	1,902
Sept. 1	2,280	2,493	2,665
Oct. 1	2,745	2,999	3,159

Planting Rate

Research and experience continue to prove that the number of ears produced per acre is a more important influence on yield than the size of ears. Big, 1-pound ears are nice to look at, but more likely they indicate that plant population was too low rather than that there will be a high yield. A higher yield would have resulted from more plants and smaller ears. On the other hand, too many plants for the fertility level, moisture supply, and weather conditions will result in barren plants and poorly pollinated ears.

The optimum planting rate might be defined as the one that will result in the maximum population that can be supported with normal rainfall and distribution without excessive barren plants or pollination problems. This population will be slightly more than optimum in years with less than normal rainfall and probably less than optimum in years of higher but not excessive rainfall.

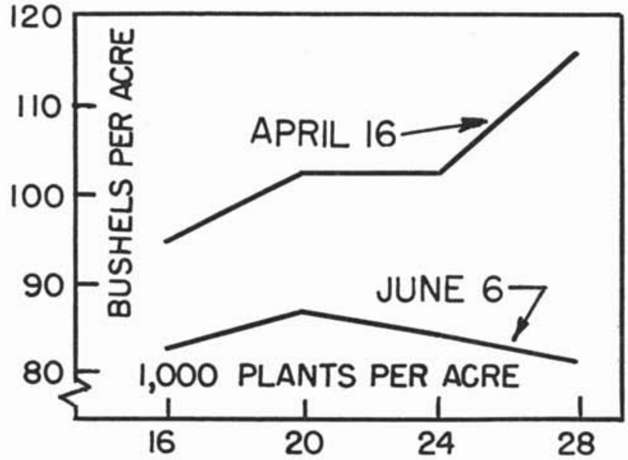
Many facts must be known before determining the optimum population for a particular field. These include:

1. The crowding tolerance of the variety. Varieties differ in their ability to tolerate high populations (Table 1).

2. The fertility level, especially nitrogen. Increase the amount of nitrogen applied as population increases (Table 2).

3. Row width used. Population can usually be increased 2,000 to 4,000 plants per acre when rows are narrowed from 40 inches to 30 or 20 inches without any serious increase in barrenness or pollination problems. The result is an increase in yield (Table 3).

4. Planting date. Varieties that tolerate high plant populations may be planted at a higher population when planted early than when planted late (Fig. 1). There



Planting date and population, Dixon Springs, 1968. (Fig. 1)

Table 1. — Effect of Crowding on Corn, Urbana, Illinois, 1966

Variety	Plants per acre planted in 30-inch rows		
	16,000	24,000	32,000
		Bushels per acre	
A	127	140	153
B	126	98	62

Table 2. — Effect of Nitrogen and Plant Population on Corn Yields, Northern Illinois Experiment Field

Nitrogen	Plants per acre		
	16,000	22,000	28,000
Pounds per acre		*Bushels per acre*	
0	88	83	76
240	139	148	158

Table 3. — Effect of Row Width on Corn Yield, Urbana, Illinois, 1964-66

Plants per acre	Row width	
	40 inches	30 inches
	Bushels per acre	
16,000	127	132
24,000	133	144
32,000	126	138

are several reasons for this. First, the early planted corn is shorter. Second, the early planted corn is more likely to pollinate during a period with favorable rainfall and temperature. Third, less of the subsoil moisture reserve has been used up. Moisture stress during the pollinating period is aggravated by high population.

In summary, a specific recommendation on planting rate is impossible unless such facts as the soil type, fertility level, date of planting, and so on, are known. If you are changing varieties or making a major change in some other practice, increase the population by 2,000 to 4,000 plants per acre over that which you normally use. Do this in two or three places in the field and check the effect of the increase in the fall.

Research in Progress

High-lysine corn made its commercial debut in 1969 and more seed will be available in 1970.

Lysine is one of the amino acids essential to animal life. Ruminants need not be concerned whether the protein they eat contains this amino acid because the microflora in their rumen can synthesize lysine from lysine-deficient protein. Non-ruminants cannot do this, so swine, poultry, and humans must have a source of protein that contains sufficient lysine to meet their needs.

Normal dent corn is deficient in lysine. The discovery in 1964 that the level of this essential amino acid was controlled genetically and could be increased by incorporating a gene named Opaque 2 was exciting news to the corn geneticist and the animal nutritionist.

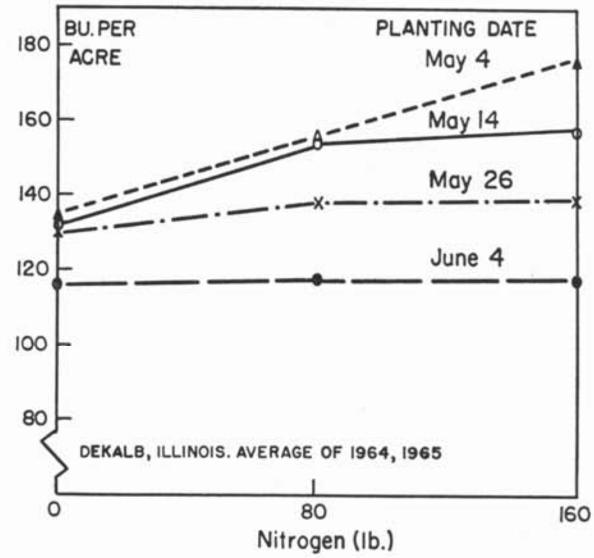
The potential value of this discovery to the swine farmer was obvious when feeding trials demonstrated that growing swine needed very little additional protein when fed high-lysine corn.

Early agronomic research work with high-lysine corn indicated that it might be slightly lower in yield and higher in moisture than its normal counterpart. Another disadvantage was its softer kernel which sometimes contributed to greater stand losses under adverse weather conditions.

Current research with more sophisticated hybrids indicates that the differentials in yield may be overcome. Continued work will probably solve the other problems in the future.

Swine growers should explore the possibility of growing high-lysine corn.

Liguleless or upright-leaved corn development and research indicates these types are more tolerant of high populations. One form of the upright leaf angle is controlled by a gene known as liguleless. Upright leaves in the upper part of the corn plant allow more light to penetrate deeper into the leaf canopy, providing more solar energy for leaves in the lower half of the plant at the ear-shoot level.



Supporting practices, in this case date of planting, often determine the most profitable nitrogen application. (Fig. 2)

Illinois researchers have shown that as the corn leaf becomes more upright the amount of photosynthesis done by a given area of a leaf is slightly less. However, the upright leaves allow more light to penetrate into the canopy and enable the lower leaves to conduct photosynthesis at a greater rate than under heavily shaded conditions. Better distribution of light energy over the plant should return a higher yield.

Nitrogen Applications for Corn

Rate. The most profitable rate for nitrogen depends not only on the cropping system and amount of manure applied, but also on the kind of job a farmer does in growing corn (Fig. 2).

In the experiment in Figure 2, following a legume catch crop, late-planted corn did not respond to nitrogen. The May 14 planting responded well to 80 pounds, and the May 4 planting to 160 pounds or more.

In other experiments profits from various levels of nitrogen were increased by increasing the plant populations.

Farmers who make better choices of planting date, hybrid, population, and weed-control practices may profitably apply far more nitrogen than their neighbors for the same kind of soil and cropping system. The following suggestions are therefore only general guides for typical situations.

The idea is widespread that you should apply 1 pound of potassium for each pound of nitrogen. It is not based on any research or reliable farm comparisons.

Much has been made of the effect of nitrogen-potassium balance on stalk rot. Research has clearly shown that the combination of high nitrogen and low potassium often accentuates stalk rot. But there is no evidence that you can reduce stalk rot by adding potassium when the soil test is already high.

Situation 1. Corn in a continuous corn or corn-soybeans grain-farming system: use 125 to 250 pounds of nitrogen per acre.

The lower rate is suggested for fields where soil physical properties often limit yields to 100 bushels or less (sands and poorly drained, slowly and very slowly permeable soils). The higher rate is for highly productive soils on which excellent supporting practices are used. This combination will often produce yields of 150 bushels or more per acre.

Rates of 150 pounds or more of nitrogen per acre will increase the nitrogen content of residues returned to the soil, and this will increase the total nitrogen the soil can supply for the next corn crop.

If you plan to apply 150 pounds or more, consider a split application. You may apply 125 to 150 pounds in the fall or in the spring before planting. When the corn is 12 to 18 inches tall, evaluate your crop prospects. Estimate how well your fall or early spring application has been preserved. If you planted early, and have 20,000 or more plants per acre, weeds under control, and a good supply of subsoil moisture, then sidedress with 75 to 100 pounds of nitrogen. If the crop outlook is not favorable, you may dispense with sidedressing unless you feel that nitrogen loss from your previous application was large.

Situation 2. Corn following soybeans, a small grain (no catch crop), or one year of corn in a farming system that includes a legume hay crop or catch crop once in 5 to 6 years: use 100 to 150 pounds of nitrogen per acre on dark-colored prairie soils and 125 to 150 pounds on light-colored timber soils.

Apply the lower rate in either case where soil physical properties limit yields to only 80 to 100 bushels with good management. The higher rate is suggested for superior management on soils with 5-year average yields in the 100- to 125-bushel range. These soils will produce 150 to 180 bushels in the best years without uneconomically heavy rates of fertilizers.

Situation 3. Corn following a good legume sod or 10 tons of manure per acre: use 75 to 150 pounds of nitrogen per acre.

Dark prairie soils with a good legume sod or 10 tons of manure will usually supply enough nitrogen for 100 bushels of corn per acre. Farmers who aim for 150 to 180 bushels will need to apply 100 to 150 pounds of nitrogen per acre.

For light-colored timber soils and the claypan soils in south central Illinois, 100 to 125 pounds of nitrogen are suggested. The top rate is less than for dark soils because yield potentials are less.

Which nitrogen fertilizer? Each nitrogen fertilizer has certain advantages and disadvantages over all others. For many uses on a wide variety of soils, all of them are likely to produce about the same yield increases.

One exception is that fertilizers containing a considerable part of the nitrogen in nitrate form are not suitable for fall application on any soil or early spring application on sandy soils because of the likelihood of leaching. Nor are they suitable for soils that are often very wet in April and May because of possible loss by denitrification. Anhydrous ammonia probably has a slight advantage for fall application because the high NH_3 concentration delays nitrification and thus keeps more of the nitrogen in the ammonium form, so that it cannot be lost by leaching or denitrification. Ammonium sulfate increases the acidity of acid and alkaline soils. So when you figure the actual cost of ammonium sulfate you should add 1 to 2 cents per pound when applying it on acid soils and deduct 1 or 2 cents when using it on alkaline soils.

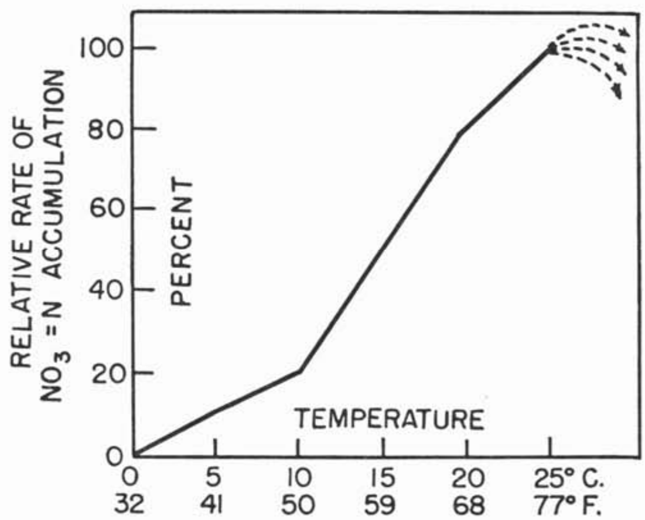
Time of Nitrogen Application Reviewed

Although there was more nitrogen on the average acre in 1969 than in any previous year, nitrogen deficiency symptoms were more widespread on corn than in years.

It has been asked if fall application was oversold. Fall and spring preplant applications of nitrogen were, in fact, less than in most recent years. The greatest amount of nitrogen was applied as a sidedressing. The increase in nitrogen deficiency symptoms proves the point that nitrogen can be lost under certain weather conditions even with the best nitrogen fertilization plan.

Nitrogen is lost by denitrification or leaching. *Only nitrogen in the nitrate form can be lost by either route.*

Nearly all of the nitrogen applied in the Midwest is in the ammonium form or converts to ammonium (anhydrous ammonia and urea, for example) soon after appli-



Influence of soil temperature on the relative rate of NO_3 accumulation in soils. (Fig. 3)

cation. Ammonium nitrogen is held by the soil clay and organic matter and cannot move very far until after it nitrifies (changes from ammonium to nitrate).

Whether the ammonium nitrifies in the fall depends mainly on soil temperature after application (Fig. 3). Agronomists generally suggest that fall application be delayed until the soil temperature at 4 inches deep is 50° F. or less. The reason for this is that nitrification (in comparison with 60° F.) proceeds only one-half as rapidly at 50° F., 1/10 as rapidly at 40° F., and stops completely at 32° F. *Average dates* on which these temperatures are reached are not satisfactory guides to use because of great variability from year to year. Local dealers and farmers can make good use of soil thermometers to guide fall nitrogen applications.

Temperatures in the fall of 1968 were below normal in October and December and above normal in November, so soil temperature was likely near average until freeze-up time and conversion to nitrate was about typical. March, 1969, temperatures were well below average, but this was offset by slightly above normal temperatures for April and May. Up to June 1, 1969, the conversion of nitrogen to the nitrate form was probably somewhat above normal. In Illinois most of the nitrogen that is applied in late fall or very early spring *will be converted to nitrate by corn-planting time*. Though the rate of nitrification is slow (Fig. 3), the period of time is long during which the soil temperature is between 32° F. and 40° to 45° F.

Locally heavy rainfall in June and July undoubtedly caused large losses of nitrogen in many sections of the state in 1969.

Denitrification. Denitrification is believed to be the main pathway of nitrate and nitrite nitrogen loss, except on sandy soils where leaching is more important. Denitrification involves only nitrogen that has already been converted from the ammonium form to either nitrate (NO_3^-) or nitrite (NO_2^-).

The amount of denitrification depends mainly on: (1) how long water stands on the soil surface or how long the surface is *completely saturated;* (2) the temperature of the soil and water; and (3) the pH of the soil.

When water stands on the soil or when the surface is completely saturated in fall or early spring, nitrogen loss is likely to be small because (a) much nitrogen is still in the ammonium rather than nitrate form and (b) the soil is cool and the denitrifying organisms are not very active. Unfortunately, the wet weather in 1969 was in June and July in many areas, thus maximizing denitrification losses.

Many fields in east central Illinois and to a lesser extent in other areas have low spots where surface water collects at some time during the spring or summer. The flat claypan soils also are likely to be saturated though not flooded. Sidedressing would avoid the risk of spring loss on these soils, but would not affect midseason loss. Unfortunately, these are the soils on which sidedressing is difficult in wet years.

The higher the pH the more rapid the denitrification loss, being almost twice as rapid at pH 6.8 as at 6.0.

Denitrification is difficult to measure in the field, but several laboratory studies show that it can happen very fast. At temperatures that are common in midsummer, most nitrate nitrogen can be lost within 3 to 5 days at pH 6.0 or above.

Leaching. Except on sandy soils leaching probably did not move large amounts of nitrates either beyond normal midsummer rooting depth or into tile lines in 1969.

The fact that 6 or more inches of rain fell in some areas in a short time does not mean that 6 inches of water moved through the soil, thus flushing out nitrates. The infiltration capacity (rate at which water can enter the soil) of silty and clay soils is not high enough to allow all of the rain to enter the soil during high-intensity rainfalls. Most of the water runs off the surface either into low spots or into creeks and ditches.

In many fields the soil was already saturated during rainy periods, hence further rainfall either ran off or ponded on the surface in low spots. In either case it did not simply move all of the nitrates down or out of the soil except in low spots where one to two feet of water moved down to the tiles.

One inch of rainfall moves down about one-half foot in silt loams and clay loams, though some of the water moves farther in large pores through the profile and carries nitrates with it.

In sandy soils each inch of rainfall moves nitrates down about one foot. If the total rainfall at one time was more than 6 inches, little nitrate will be left within rooting depth.

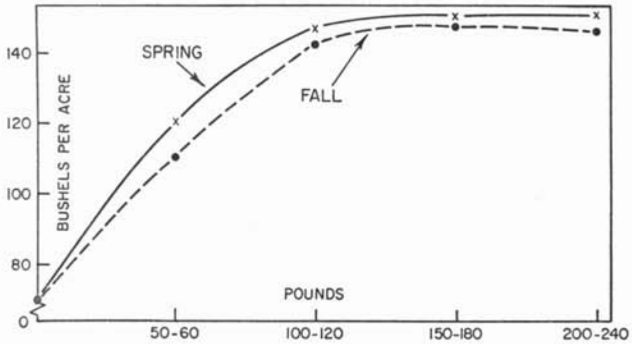
Between rains there is some upward movement of nitrates in moisture that moves toward the surface as the surface soil dries out.

Corn roots usually penetrate 5 to 6 feet in Illinois soils. Thus nitrates that leach 3 to 4 feet are well within normal rooting depth.

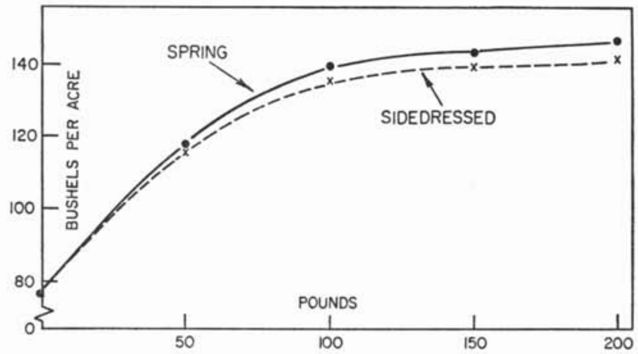
Fall, spring, and sidedressed nitrogen. In recent years farmers in central and northern Illinois have been encouraged to apply nitrogen in the fall in non-nitrate form at any time after the soil temperature at 4 inches is below 50° F., except on sandy, organic, or very poorly drained soils.

Fall application is not recommended on sandy soils. It is highly questionable in the southern one-third of Illinois because of mild winters and in the claypan area because soils are often saturated after they warm up enough to convert ammonium to nitrate.

The 50° F. level for fall application is believed to be a realistic guideline for farmers. Applying nitrogen earlier involves risking too much loss. Later application involves



Yield of corn, fall vs. spring application of ammonium nitrate, 14 trials, 1966 to 1968, in central and northern Illinois. DeKalb, Carthage, Hartsburg, and Carlinville experiment fields. (Fig. 4)



Yields from nitrogen applied in the spring before planting and from sidedressed nitrogen, four-year average, 1965 to 1968, DeKalb. (Fig. 5)

risking wet or frozen fields which would prevent application and fall plowing.

Results from 14 experiments in central and northern Illinois from 1966 to 1968 (Fig. 4) show that fall was a somewhat less effective time than spring *to apply ammonium nitrate.* In fact, 100 to 120 pounds applied shortly before planting was equal to 125 to 140 pounds applied in the fall. Remember that in these experiments half the N source was in nitrate form. Unfortunately, no results are available to compare fall, spring, and sidedressed applications of a nitrogen source that is entirely in the ammonium form.

One-half of the nitrogen in ammonium nitrate is in nitrate form. The effectiveness of fall applications in these experiments would likely have been greater if an all-ammonium form had been used. No explanation is offered for the failure of the highest rate to offset the lower efficiency from fall-applied N.

Late fall and early spring applications of ammonium sources differ little in their susceptibility to denitrification and leaching loss because of the date at which nitrates are formed and the conditions that prevail thereafter. Both are, however, more susceptible to loss than is nitrogen applied at planting time or as a sidedressing. Four-year average yields for both spring and sidedressed nitrogen are shown in Figure 5. Spring application was slightly superior mainly because it was positioned deeper, an advantage in the two relatively dry years.

Anhydrous ammonia nitrifies more slowly than other ammonium forms and, therefore, is slightly preferred for fall applications. It is well suited to early spring application when the soil is dry enough for good dispersion and closure of the applicator slit.

The combination of denitrification and leaching readily explains why corn in many fields showed nitrogen deficiency in August, 1969, and why yield results from fall application were not as good as in previous years.

Why not apply all nitrogen shortly before planting or as a sidedressing?

There is no simple answer. The hundreds or perhaps thousands who planned to sidedress in 1969, but were prevented from doing so because wet soil made it impossible to get into the fields until silking time, will probably give more favorable consideration to preplant applications for the next year. Other farmers had a similar experience in localized areas in previous years.

If most of the nitrogen were to be sidedressed, the cost would increase because of the extra local storage capacity and application equipment needed to meet the surge of demand during a short time.

If the sidedressing season was rainy, many fields would not be fertilized with nitrogen. That would reduce farmers' income more than would the typical lower efficiency from fall and early spring application.

Fall and early spring applications often, though not always, compete less with other farm work than does application either at planting or later. Such applications minimize the likelihood of ammonia injury to seedlings from anhydrous or solutions that contain free ammonia. In addition, up to 1968 and 1969 fertilizer dealers reduced prices on fall applications.

Sidedressing through knives may prune roots, thus making the plants more susceptible to drouth and increasing the amount of stalk rot which enters through broken roots. This can be reduced or avoided by early sidedressing soon after the corn emerges.

A disadvantage of preplant application, in addition to risk of denitrification and leaching, is that you cannot recover the nitrogen if the crop floods out or is not planted.

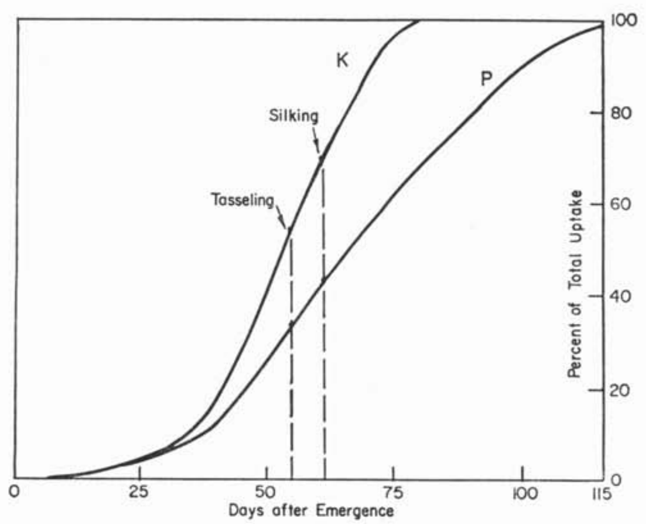
Farmers who plan to apply 180 pounds or more may want to consider applying two-thirds in the fall and the remainder as a sidedressing. At sidedressing time the farmer can appraise his yield prospect and modify the amount of nitrogen accordingly. If he planted early, has 20,000 or more plants per acre, controls weeds, and has adequate soil moisture, then he can apply an extra large amount. If any factor is unfavorable, he can reduce the sidedressing.

The cost of nitrogen is now so low that even moderate loss of N is a relatively small factor in deciding when to apply nitrogen. Of more concern is the fact that increasing the rate has often not offset the lower efficiency of fall application.

Another major concern is the fate of the nitrogen that is lost. If most of it returns to the air through denitrification, there is no problem. But if a substantial portion leaches downward into ground water, steps will likely be taken at some future date to restrict fall and early spring applications.

Secondary and Micronutrients

No deficiencies of secondary nutrients (calcium, magnesium, sulfur) have been identified on corn in Illinois where soil is pH 5.5 or above.



Uptake of phosphorus (P) and potassium (K) by corn through the growing season. (Hanway, Iowa State University) (Fig. 6)

Micronutrients to watch are zinc, iron, manganese, copper, and boron. A few farmers and fertilizer dealers have reported suspected cases of deficiencies of one or more of these micronutrients, but none has been verified by research trials in Illinois.

The Department of Agronomy at the University of Illinois is continuing to run spectrographic analyses of plants from several research fields and has begun an important new project to learn the nutrient status of corn and soybeans in Illinois as described on page 41.

Phosphorus and Potassium Uptake

Phosphorus continues to be taken up by corn until the grain is fully developed. Most of the potassium has been taken up soon after silking (Fig. 6). This indicates the need for different interpretations of phosphorus and potassium tests, based on characteristics of the subsoil.

Soil factors that influence the depth and extensiveness of rooting and the amount of available phosphorus in the *lower subsoil* are important in interpreting the phosphorus test (page 37). Subsoil phosphorus is especially important in drouth periods when roots cannot feed effectively near the surface.

In contrast to the situation for phosphorus, soil conditions in the *plow layer* and *upper subsoil* are more critical in interpreting the potassium test (page 39). Before the root system has reached maximum depth the plant has satisfied its need for potassium.

Phosphorus Applications for Corn

See page 37 for suggested P_1 soil test goals and page 38 for a discussion of soil tests that are very high. The amounts shown for broadcast applications in Table 4 at low P_1 test levels provide for considerable build-up, but the amounts shown for drill applications do not. Where there is a range in the amount suggested under

Table 4. — Available Phosphorus to Apply for Corn and Soybeans, Based on P_1 Soil Tests

P_1 test: Soil region (see page 37)			Percent of possible yield	Pounds of P_2O_5 or P to add per acre based on the P_1 test: P_2O_5		P	
Low	Medium	High		Broadcast	Through planter or drill	Broadcast	Through planter or drill
20	10	7	69	or (a) 90 to 150 +	20 to 40[b]	or (a) 39 to 65 +	9 to 17
25	15	10	83	(b)	40 to 60[b]	(b)	17 to 26
30	20	15	90	60 to 120 or	30 to 40[b]	26 to 52 or	13 to 17
38	30	20	97	60 or	20 to 30[b]	26 or	9 to 17
45[a]	40[a]	30[a]	98+	Phosphorus may be applied to maintain the soil test. Little or no response likely in the year of application.			

[a] See also tentative goals for the P_1 test on page 38.
[b] The highest drill rates are all that can profitably be placed in the band, but they will have little effect on the soil test in following years and hence do not substitute for larger amounts broadcast for rapid buildup.

the heading "Broadcast," the larger figure will give a quick increase in P_1 test, the smaller figure will give only a small increase.

Annual phosphorus removal by corn is about 36 pounds of P_2O_5 (16 pounds of P) in 100 bushels of grain. Fifty to 70 pounds of P_2O_5 will be needed just to maintain the P_1 test level. You may apply it each year, but proportionately larger amounts at two- to three-year intervals are equally good. Use these general guides only until the field is resampled and tested.

Harvesting the crop for silage increases removal to about 60 pounds of P_2O_5 (27 pounds of P), but 80 percent of this phosphorus is recovered in manure when silage is fed to animals and will usually be returned somewhere on the farm.

Several states have reported that unnecessarily high phosphorus levels have caused zinc deficiency. Isolated cases of magnesium deficiency have also been reported. Neither situation has been identified in Illinois. For more information see page 42.

Potassium Applications for Corn

See Table 33, page 40.

Buildup and Maintenance

You may choose to build up your soils to the desired test levels (pages 37 and 40) in just a few years, or more gradually over a five- to ten-year period. If you choose the slower buildup, row fertilization will be helpful to obtain optimum yields.

There are several reasons why raising the soil tests for P and K with fertilizer is much slower than most people expect. First, the soil tests are in terms of the elements whereas fertilizer analyses are in the oxides P_2O_5 (43.6 percent P) and K_2O (83 percent K). Second, a crop often removes an amount equal to one-half to three-fourths of the amount applied. Third, phosphorus in fertilizers soon changes to forms that are only partly extracted by soil tests; some of the potassium moves back between the clay sheets and is not picked up by the test.

You may make buildup applications at any convenient point in the cropping system and at any time of year, except on bare, sloping, frozen fields.

After the desired soil-test levels have been reached, there is no reason to believe that continued annual broadcast applications are necessary. Larger applications every two or three years are more economical.

Some farmers are substituting chisels or field cultivators for moldboard plows, especially following soybeans. Chiseling and cultivating will mix the nutrients only 3 to 4 inches deep. On soils that test medium to high throughout the plow layer, it is doubtful that one could measure the difference in yield between having the most recently applied fertilizer 3 inches deep or 9 to 10 inches deep. Plowing once in four or five years will provide for adequate mixing.

On soils that are low enough in test and in supplying power to result in a large yield response to the fertilizer applied in the current year, there is likely to be a significant advantage for deeper placement, especially in dry seasons.

For more information on chiseling see page 40.

Row fertilization. Experimental results from row fertilization in central Illinois and farther south indicate that yield responses are rare on soils that have been built up to a high fertility level. But farmers in central and northern Illinois who plant very early may experience the cool, wet soil conditions typical of the usual planting dates in states farther north where row application is more popular and more effective.

Corn seedlings need a high concentration of available phosphorus. You can supply it either by raising the soil test of the whole plow layer to a high level or by adding a small amount near the seed where the soil test is medium or above (see also "Pop-up" fertilizers below). Phosphorus is the most important component of so-called "starter" fertilizers. Nitrogen in the fertilizer band enhances the uptake of phosphorus, so suggested ratios of N to P_2O_5 are from 1:2 to 1:4. Fifty percent water solubility of the phosphorus is adequate for the amounts applied in typical situations of soil test level and pH. On alkaline soils, higher water solubility is preferred.

Pop-up. Pop-up fertilizer will make corn look very good early in the season and may aid in early cultivation for weed control. But there is not likely to be a substantial difference in yield produced in most years by a so-called pop-up application or by fertilizer that is placed in a band to the side and below the seed. With these two placements there will seldom be a difference of more than a few days in the time the root systems intercept the fertilizer band.

"Pop-up" fertilization means placing 40 to 50 pounds of fertilizer in contact with the seed. Research in many states over a long period of time has shown that, for starter effect only, you should place fertilizer as close to the seed as safety permits. The old split-boot applicator gave more starter effect than the modern side placement equipment that places fertilizer 1½ inches to the side and 1½ inches below seed level.

Many farmers have built up the general fertility level of their soil to the point where they are interested in a small amount of fertilizer mainly for an early growth effect.

Farmer interest in pop-up fertilization in Illinois results from the fact that fewer stops are required at planting time because the application rate is reduced to about one-half.

Use a fertilizer with all three major nutrients in a ratio of about 1-4-2 of N-P_2O_5-K_2O (1-1.7-1.7 of N-P-K). The maximum safe amount of $N + K_2O$ for pop-up placement is about 10 to 12 pounds in 40-inch rows and correspondingly more in 30- and 20-inch rows. It is, in fact, necessary to apply more in narrow rows in order to have an equal amount per foot of corn row.

The term "pop-up" is a misnomer. The corn does not emerge sooner than without it, and it may come up one or two days later. It may, however, grow more rapidly during the first one to two weeks after emergence. Some people think that with pop-up applications the fertilizer is mixed with the seed. This is incorrect. The tube from the fertilizer hopper is repositioned to discharge the fertilizer in contact with the seed.

Crops For Late Planting

In most years flooding or some other disaster makes replanting of corn and soybeans necessary somewhere in Illinois.

When this happens the most common questions are: Is it too late to replant with corn or soybeans? If it is not too late, how early a variety should be used? If it is too late for corn or soybeans is there any other crop that can be substituted for feed grain or cash-grain production.

Any answer to these questions assumes that (1) weather conditions following replanting will favor immediate germination and emergence, (2) that rainfall and temperatures will favor normal growth and development, and (3) that the first killing frost in the fall will be as late or later than average.

The following are estimates of how late corn and soybeans may be planted in Illinois when favorable weather and growing conditions follow replanting.

Starting in the northwestern corner of the state where the first killing frost can be expected before October 5, June 15 is the latest date that early varieties of corn can be planted with reasonable assurance that they will be mature (30 to 35 percent moisture) before the first frost. Make the shift to early varieties in late May.

As the average date of the first killing frost moves later into October the latest date for planting corn for grain moves later into June.

In the northern third of the state you can move the planting date later into June about the same number of days that the first frost falls after October 5.

In the southern two-thirds of the state (this is especially true of the southern one-third) you can move the planting date proportionally later into June because of the higher temperatures during the remainder of the growing season. In central Illinois where the average killing frost occurs on October 15, corn planted as late as July 5 has a 50-percent chance of maturing before frost.

Unless the need for grain or silage is especially great, planting corn later than July 5 to 10 is of questionable merit because yields are likely to be low.

Soybeans have the ability to greatly shorten their vegetative period and may be planted later than corn with reasonable assurance that they will mature before frost. In northern Illinois, where the first killing frost is expected about October 5, early varieties such as Chippewa 64 and Hark may be expected to mature when planted as late as the last of June. The later varieties, such as Harosoy 63 and Corsoy, may be used until the middle of June.

In north central Illinois you can plant Harosoy 63 and Corsoy until early July and you can use varieties of the maturity of Amsoy until mid-June.

In central Illinois Wayne and varieties of similar maturity may be expected to mature when planted by mid-June. Use Amsoy, Harosoy 63, and Corsoy until July 5 to 10.

The growing season in southern Illinois is long enough that most of the varieties normally grown in the area will mature when planted as late as July 5 to 10.

When you must plant soybeans late, use the tallest variety that has a reasonable chance to mature. One of the problems with late-planted soybeans is short plant height and low podding. Dry weather aggravates this.

Other grain crops that mature in a short time and may be used in an emergency are sorghum and buckwheat.

Varieties of sorghum that will mature in 90 to 100 days are sometimes used for late planting. The penalty for planting sorghum late is often not so great as it is for corn and other crops. If the crop is being grown as a cash crop, arrangements for a market should be made ahead of planting. Some elevators prefer not to handle sorghum. Local livestock feeders or feed mills may be interested in the crop.

Another problem usually associated with sorghum is that of drying the grain. The grain should be harvested as soon as it is mature. Often this will be before the plant is dry and the grain will be too wet to store without drying.

Buckwheat may mature in 75 to 90 days. It can be planted as late as July 10 to 15 in the northern part of the state and late July in southern Illinois.

The crop is sensitive to both cold weather and hot weather. It will be killed by the first frost in the fall. Yields will be disappointingly low if it blooms during hot weather.

The market for buckwheat is limited unless you plan to use it for livestock feed. Be sure of a market before you plant it.

SOYBEANS

The 1969 Season

Soybeans exceeded expectations in much of Illinois, with a record yield of 32.5 bushels.

Planting got off to a good start in all but the southern quarter of the state. Cool, wet weather followed throughout northern Illinois, and very dry weather prevailed throughout the east central region. Southern Illinois had continuing wet weather which interferred with the planting of soybeans.

Cool, wet weather in northern Illinois after planting slowed the growth rate of the soybeans, but weeds continued to grow well. Wet soils prevented cultivation, so fields without effective preemergence herbicides became very weedy. Many low spots drowned out or suffered water damage. At the end of the season the water-damaged soybeans were less evident than water-damaged corn.

Very dry conditions through the east central region of Illinois resulted in spotty emergence of soybeans. Some beans lay in the soil two weeks before emerging. Spotty emergence was very common in this region. At harvest time late-germinating spots were not very noticeable. The warm summer with good subsoil moisture supply helped late-emerging beans catch up with the earlier emerging beans in the field.

Continued wet weather in southern Illinois resulted in drowned out spots and some fields were never planted. A dry, warm August and September helped the beans develop at nearly normal rates.

Seed Source

To insure growing a good crop you must do a good job of selecting seed. When evaluating seed quality, consider the percent of germination; percent of damaged seeds; presence of disease; percent of insects, weed seeds, and inert material; and percent of pure seed.

Table 5. — Uncertified Soybean Seed Analysis by Seed Source

	Germination	Pure seed	Weed seed	Inert matter	Other crops
	Percentages				
Home grown	79.6	95.5	.02	2.29	2.27
Neighbor grown	80.8	97.5	.01	2.06	.41
Seed dealer	81.2	97.8	.001	1.48	.77

Table 6. — Certified and Uncertified Soybean Seed Analysis

	Samples	Germination	Pure seed	Weed seed	Inert matter	Other crops
	Percentages					
Uncertified	79.6	80.2	95.5	.02	2.6	2.0
Certified						
With Tags	12.3	84.2	98.7	.001	1.2	.2
Without Tags	8.1	77.6	94.9	.002	2.1	3.0

Samples of soybean seed taken from the planter box as farmers were planting showed that 66 percent was home-grown seed, 9.2 percent was purchased from seed dealers, and 6.8 percent came from elevators. Home-grown seed was inferior to other sources of supply (Table 5). The germination and pure seed content of home-grown seeds were lower than with seeds from other sources. Weed seed content, inert material (hulls, straw, dirt, and stones), and other crop seeds (particularly corn) were higher.

Farmers who purchased certified seed obtained a higher quality seed on the average than farmers purchasing uncertified seed. Samples reported to be certified, but without the certification tag attached, were lower in seed quality than those with certified tags (Table 6).

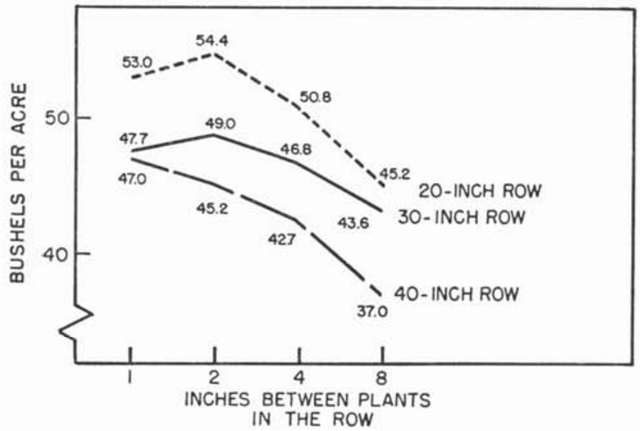
This evidence indicates the Illinois farmer could improve the potential of his soybean production by purchasing higher quality seed than he has in the past. The home-grown seed is the basic problem. Few farmers are equipped to carefully harvest, dry, store, and clean seeds, and to perform laboratory tests adequately to assure himself of high-quality seed. Agriculture today is a professional enterprise. If a farmer is not a professional seed producer and processor, he may be well advised to market his soybeans and obtain high-quality seed from a reputable professional seedsman.

The state seed tag is attached to each legal sale from a seed dealer. Read the analysis and consider if the seed being purchased has the desired germination, purity of seed, and freedom from weeds, inert material, and other crop seeds. The certified tag verifies that an unbiased non-profit organization (the Illinois Crop Improvement Association) has conducted inspections in the production field and in the processing plant. These inspections make certain the seeds are of a particular variety as named and have met certain minimum seed-quality standards. Some seedsmen may have a higher seed quality than others. It pays to read the tag.

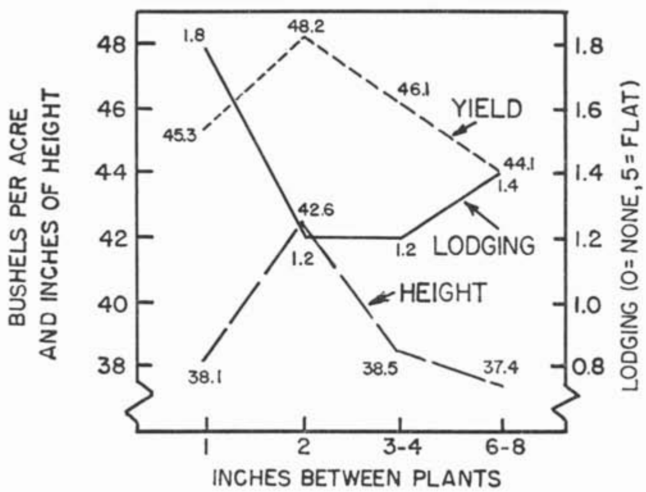
Plant Population

Space soybean plants so they are about 2 inches apart at maturity if row widths are 20 to 30 inches wide. Space plants nearer to 1 inch apart in 40-inch rows (Fig. 7). If soybeans are planted in 8- or 10-inch rows, providing 6 inches of space between plants has produced highest yields.

Soybean plants are usually taller at higher plant populations. However, in 30-inch rows, plants spaced 1 inch apart in the row were shorter and lower yielding than plants spaced 2 inches apart in the row (Fig. 8). The



Row width and plant spacing of two soybean varieties, Urbana, 1968. (Fig. 7)



Plant spacing of soybeans in 30-inch rows, Urbana, 1967-68. (Fig. 8)

increased competitive effects of closely spaced plants resulted in shorter growth and more lodging.

Lodging was a big problem with 1969 soybeans in Illinois. It can be aggravated by excessive plant populations. The least lodging occurred at the highest yields where plants were spaced 2 to 4 inches apart in the row (Fig. 8).

Row Width

Yield records (Fig. 7) continue to show an advantage for rows narrower than 40 inches. Illinois farmers are changing to narrow rows as equipment changes allow them to do so. The trend for more soybeans in 20- to 30-inch rows and fewer in wider rows can be seen in Table 7.

Soybeans average about 15 percent higher in yield in 20- to 30-inch rows than in 40-inch rows. The yield of short varieties in narrow rows may be greater than 15 percent higher than in wide rows. The yield advantage for tall varieties in narrow rows may be 15 percent or less over wide rows. Late-planted soybeans benefit relatively more when planted in narrow rows as compared with wide rows because soybeans grow shorter when planted late. Short-statured plants do not fill in the middles of wide rows very rapidly, if at all.

Varieties

Soybean varieties are divided into maturity groups according to their relative time of maturity. Varieties of Maturity Group I are nearly full season in northern Illinois, but too early for good growth and yield farther south. In extreme southern Illinois the Maturity Group IV varities range from early to midseason in maturity.

Maturity Group I

Chippewa 64 is an early variety adapted to the northern states and performs like its namesake Chippewa, except that it carries resistance to phytophthora root rot. Chippewa and Chippewa 64 account for about two-thirds of the soybean acreage in Wisconsin and Minnesota, but grow them only in northern Illinois and only when you want earliness, since the later varieties outyield them throughout Illinois.

Hark is a variety adapted to northern Illinois where it has yielded as well as most Group II varieties, but less than Amsoy. It has good height for an early variety, but has a tendency to shatter when grown in central Illinois where it ripens early while the weather is still warm. This variety, like Wayne, may show iron-deficiency chlorosis when planted on soils of high pH (7+).

A-100 is an early variety similar to Hark in maturity. It is a farmer selection from Minnesota. It is shorter than Hark but more resistant to shattering and has yielded about the same as Hark. Its tendency to lodge is slightly greater than Hark.

Bombay variety has had limited testing in Illinois. It is a farmer selection that appears to be more susceptible to lodging and lower in yield than Hark or A-100 in northern Illinois.

Disoy is a large-seeded variety released in 1967 from Iowa State University. It is susceptible to phytophthora root rot. The yield record of Disoy is similar to Chippewa 64, but less than A-100 or Hark. Disoy matures about 3

Table 7. — Row Spacing of Soybean Acreage in Illinois

Row width, inches	Percent of acreage		
	1967	1968	1969
22 or less	2	1	1
23–30	22	26	30
31–36	17	14	15
37 or more	59	59	54

Table 8. — Characteristics and Parentage of Major Soybean Varieties in Illinois

Maturity group and variety	Parentage and year released[a]	Flower color	Pubescence color	Pod color	Seed luster	Hilum color[b]
0						
Grant	Lincoln X Seneca (1955)	white	lt. brown	brown	shiny	black
Traverse	Lincoln X Mandarin (Ottawa)(1965)	white	gray	brown	shiny	yellow
I						
Chippewa	$Lincoln^2$ X Richland (1954)	purple	brown	brown	shiny	black
Chippewa 64	$Chippewa^8$ X Blackhawk (1964)	purple	brown	brown	shiny	black
Bombay	farmer selection (1966)	purple	gray	tan	shiny	yellow
Hark	Hawkeye X Harosoy (1966)	purple	gray	brown	dull	yellow
A-100	farmer selection (1959)	white	gray	brown	shiny	buff
II						
Harosoy	Mandarin $(Ottawa)^2$ X AK (Harrow)(1951)	purple	gray	brown	dull	yellow
Harosoy 63	$Harosoy^8$ X Blackhawk (1963)	purple	gray	brown	dull	yellow
Carsoy	Harosoy X Capital (1967)	purple	gray	brown	dull	yellow
Lindarin 63	$Lindarin^8$ X Mukden (1963)	purple	gray	brown	dull	buff
Magna	[Mandarin (Ottawa) X Jogun] X	purple	gray	brown	dull	yellow
Prize	[Mandarin (Ottawa) X Kanro] (1967)	purple	gray	tan	dull	yellow
Provar	Harosoy X Clark (1969)	purple	tawny	brown	dull	brown
Amsoy	Adams X Harosoy (1965)	purple	gray	tan	shiny	yellow
Hawkeye 63	$Hawkeye^7$ X Blackhawk (1963)	purple	gray	brown	dull	imp. black
Beeson	(Blackhawk X Harosoy) X Kent (1968)	purple	gray	brown	shiny	imp. black
III						
Adams	Illini X Dunfield (1948)	white	gray	tan	shiny	buff
Shelby	$Lincoln^2$ X Richland (1958)	purple	brown	brown	dull	black
Wayne	(Lincoln, Richland, CNS) X Clark (1964)	white	tawny	brown	shiny	black
Calland	(Blackhawk X Harosoy) X Kent (1968)	purple	tawny	brown	dull	black
Adelphia	(Sib of Kent) X Adams (1966)	white	gray	tan	shiny	buff
SRF 300	Soybean Research Foundation Variety (1969)	white	brown	brown	shiny	black
IV						
Clark	$Lincoln^2$ X Richland (1953)	purple	brown	brown	dull	black
Clark 63	$(Clark^7$ X CNS) X $(Clark^6$ X Blackhawk) (1963)	purple	brown	brown	dull	black
Bellatti L263	farmer selection (1965)	purple	brown	brown	dull	black
Patterson	introduced from Morocco (1965)	white	gray	tan	dull	yellow
Cutler	(Lincoln X Ogden) X Clark (1968)	purple	tawny	brown	shiny	black
Custer	(Peking X Scott) X Scott X Blackhawk (1967)	purple	gray	brown	shiny	imp. black
Kent	(Lincoln X Ogden) (1961)	purple	tawny	brown	intermed.	black
Delmar	(P.I. 70,218 X Lincoln) X FC 33,243 (1963)	white	gray	brown	dull	yellow
Scott	(Sib of Lee) (Lincoln X Richland) (1958)	purple	gray	brown	shiny	imp. black
V						
Dare	Hill X Roanoke X Ogden (1965)	white	gray	tan	shiny	buff
Dyer	Hill X $(Lee^2$ X $Peking)^6$ (1967)	purple	tawny	tawny	shiny	black
Hill	(Dunfield X Haberlandt) X Sib of Lee (1959)	white	brown	tan	shiny	brown
VI						
Ogden	Tokio X PI 54,610 (1942)	purple	gray	brown	dull[c]	imp. black
Hood	Roanoke X line from Ogden X CNS (1958)	purple	gray	tan	shiny	buff
Lee	S-100 X CNS (1954)	purple	brown	tan	shiny	black
Pickett	[(Sib of $Lee)^6$ X Dorman] X $[Lee^4$ X Peking] (1965)	purple	gray	tan	shiny	imp. black

[a] Superscript indicates the number of crosses in a backcrossing program.
[b] imp. = imperfect.
[c] Seed coat of Ogden is green. All others listed have yellow seed coat.

Table 9. — Soybean Variety Performance at Urbana, Illinois, 1966-1968

Maturity group and variety	Maturity date	Lodging	Plant height	Seed quality	Seeds per pound[a]	Seed content	
						Protein	Oil
I		*score*[b]	*inches*	*score*[c]	*number*	*percent*	*percent*
Chippewa 64	Sept. 3	1.2	31	1.9	2,800	40.3	21.8
Hark	Sept. 7	1.0	32	1.3	2,700	40.0	22.2
A-100	Sept. 8[d]	1.2[d]	32[d]	1.8[d]	2,360[d]	40.4[d]	22.4[d]
II							
Harosoy 63	Sept. 9	1.9	37	1.7	2,470	40.3	21.6
Corsoy	Sept. 10	1.8	35	1.7	2,800	39.2	22.0
Amsoy	Sept. 12	1.5	39	1.7	2,600	38.3	22.5
Beeson	Sept. 15	1.2	39	2.2	2,400	39.0	21.6
III							
Wayne	Sept. 20	1.7	42	1.7	2,680	40.8	20.7
Calland	Sept. 23	1.6	46	1.8	2,510	37.8	20.6
IV							
Clark 63	Sept. 28	1.7	44	1.3	2,910	29.6	20.6
Cutler	Oct. 2	1.6	45	1.5	2,550	39.3	20.7
Kent	Oct. 6	1.7	43	1.4	2,600	38.7	21.4

[a] USDA Regional Uniform Test average.
[b] Lodging score: 1 = erect, 5 = prostrate.
[c] Seed quality score: 1 = excellent, 5 = very poor (wrinkled, shriveled, green, moldy, imperfect seed coat, or other defects).
[d] Based on 1966 and 1967 data only.

Table 10. — Disease Resistance of Soybean Varieties

Maturity group and variety	Phytophthora root rot	Bacterial pustule	Bacterial blight	Downy mildew	Frogeye leaf spot	
					Race 1	Race 2
I						
Chippewa 64	++	−	+	−	−	−
Hark	−−	−	−	−	−	−
A-100	−	−	−	−	++	−
II						
Harosoy 63	++	−	−	+	++	−
Provar	−−	−	−	−		−−
Corsoy	−−	−	−	+		−
Amsoy	−−	−	−	+	++	−
Beeson	++	−	−	+		+
III						
Wayne	+	++	−	−−	++	+
Calland	++	−	−	+		−
IV						
Clark 63	++	++	−	−−	++	−
Cutler	+	−	−	−		+
Kent	−	−	−	+	++	++
V						
Dare	+	++				

++ = resistant; + = slightly susceptible; − = susceptible; −− = very susceptible.

Table 11. — Yields at Eight Test Locations, Average of Three Years, 1967-1969

Maturity group and variety	DeKalb	Pontiac	Urbana	Girard	Edge-wood	Trenton	Eldorado	Miller City
I								
Chippewa 64	43.5	39.8	42.8	....	....	....	....	....
Hark	48.2	42.6	48.6	....	....	....	....	....
II								
Corsoy	54.8	45.4	53.3	51.8	41.5	51.3	48.2	....
Amsoy	50.0	43.1	50.3	51.3	41.4	50.4	49.1	....
Beeson	49.4	42.3	48.0	46.1	43.9	48.4	50.5	....
III								
Wayne	49.2	42.4	49.3	50.0	44.7	50.5	51.6	30.6[a]
Calland	....	....	48.0	48.4	45.9	48.7	48.8	....
IV								
Clark 63	....	....	41.7	40.4	41.4	46.9	47.3	35.7
Cutler	....	....	45.3	46.2	41.8	51.2	48.5	37.3
Kent	....	....	44.3	43.3	45.5	50.5	47.8	34.9
Custer	....	....	....	....	....	39.4	44.2	40.8
Delmar	....	....	....	....	....	43.7	46.3	37.3
V								
Hill	....	....	....	....	....	....	....	37.2[a]
York	....	....	....	....	....	....	....	43.3[a]
Dare	....	....	....	....	....	....	....	39.0[a]

[a] Estimate based on two years of data.

days later than Chippewa 64 and 2 to 3 days earlier than Hark and A-100.

Maturity Group II

Harosoy and **Harosoy 63** are similar except that Harosoy 63 is resistant to phytophthora root rot. This can be of great importance on low ground or in wet springs when phytophthora can cause severe stunting and killing of susceptible Harosoy. The Harosoys were the top-yielding varieties in northern Illinois before the release of Amsoy. Continue to use Harosoy 63 on land subject to flooding or wherever phytophthora rot is a problem, since Amsoy is very susceptible. Both varieties have a tendency to shatter when conditions are overly dry at harvest time.

Corsoy was released in 1967. It is similar to Amsoy in growth habit, but averages 2 inches shorter. It is susceptible to phytophthora root rot, so grow it where this disease is not a problem. Corsoy has yielded 1 to 2 bushels per acre more than Amsoy and matured 3 to 4 days earlier. Lodging resistance of Corsoy was slightly less than Amsoy in 1969. Corsoy and Amsoy should replace much of the acreage of older Group II varieties except where phytophthora root rot is present.

Magna and **Prize** are large-seeded varieties released by Iowa State University in 1967. They are used as specialty beans in soy foods for humans. These varieties are higher in protein and lower in oil than Corsoy and Amsoy, but are similar to Harosoy 63 in these characteristics. The yield of Magna and Prize has been 17 to 18 percent lower than Corsoy and Amsoy. Their lodging resistance has been greater than Corsoy or Amsoy. They are susceptible to phytophthora root rot.

Provar was released in 1969 as a variety higher in protein than other currently grown varieties. Its yield has been slightly less than Amsoy or Corsoy. Provar maturity averages 1 day later than Corsoy and 2 days earlier than Amsoy. It is susceptible to phytophthora root rot.

Amsoy is a high-yielding variety, second only to Corsoy among the Group II varieties, and is a very popular variety. It is very susceptible to phytophthora root rot and purple stain of the seed coat. Purple stain is occasionally a problem, usually occurring in southern Illinois. The lodging resistance of Amsoy is superior to most other Group II varieties.

Beeson is resistant to phytophthora root rot. It was released by Purdue University in August, 1968. The variety has yielded nearly as well as Amsoy when root rot was not present. In the presence of root rot, Beeson has yielded much more than Amsoy or Corsoy. Beeson matures about 3 days later than Amsoy and 6 days later than Corsoy. Lodging resistance of Beeson is slightly greater than Amsoy or Corsoy. It is similar in height to Corsoy and 1 to 3 inches shorter than Amsoy. It has a spreading leaf canopy.

Maturity Group III

Wayne is a very high-yielding variety in central and south central Illinois. It has some tendency to shatter and develops iron-deficiency chlorosis (yellowing of the leaves) on high-lime soils (pH 7+). It is susceptible to pod and stem blight, so at times will have poor seed quality. Its chief advantages are resistance to bacterial pustule and high yields.

Calland has phytophthora root rot resistance and was released by Purdue University in August, 1968. Calland has yielded nearly as well as Wayne in the absence of phytophthora root rot. Where phytophthora root rot is severe, Calland has yielded much more than Wayne. Calland matures 1 to 2 days later than Wayne, averages about 1 inch taller, and has a little greater resistance to lodging than Wayne.

Adelphia was released in New Jersey in 1966 where it showed resistance to a seed-quality problem similar to the one in southern Illinois. The yield of Adelphia has been lower than Wayne and other Group III varieties. The variety has a high seed quality. Interest is being maintained in Adelphia to test for resistance to the purple stain and other seed-quality problems that often occur in southern Illinois.

SRF-300 was developed by the Soybean Research Foundation, Mason City. The variety is similar to Wayne in maturity and lodging resistance. The leaves are narrow and lance shaped. It is susceptible to phytophthora root rot. SRF-300 grows about an inch taller than Wayne. The seed of SRF-300 is somewhat smaller than Wayne seed. Seed of SRF-300 is available only from member companies of the Soybean Research Foundation.

Maturity Group IV

Clark and **Clark** 63 are similar, except that Clark 63 is resistant to bacterial pustule leaf spot and phytophthora root rot. Bacterial pustule is a very widespread leaf spot disease in southern Illinois, and in wet fields phytophthora rot can cause severe damage in that area. Neither disease will develop on Clark 63, so this is the preferred variety. The high yield and excellent lodging resistance of these two closely related varieties have made them the leading varieties in southern Illinois.

Bellatti L263 originated as a selection from Bavender Special. It is similar to Clark in yield, maturity, standability, and appearance. Bellatti L263 was released in 1965 by Mr. Louis Bellatti, Mt. Pulaski.

Patterson was released by the High Plains Research Foundation of Plainview, Texas. It is as early as other Group IV varieties used in Illinois, and was tested at five locations in the state in 1966. It matured later than Clark 63 and earlier than Kent, but was distinctly lower in yield (5 to 40 percent below Clark 63) and had poor standability.

Cutler is a high-yielding variety that is moderately susceptible to phytophthora root rot. Cutler was released in August, 1968, by Purdue University. In the absence of phytophthora root rot, Cutler yields 3 to 4 bushels more than Clark 63 and 1 bushel more than Kent. Cutler is 2 to 3 days later maturing than Clark 63 and 5 days earlier than Kent.

Custer variety is resistant to soybean cyst nematode and phytophthora root rot. It was released from the University of Missouri in 1967. Custer matures 7 days later than Clark 63, has less lodging resistance, grows about 4 inches taller, has lower oil and protein percentages, and has yielded 2 to 3 bushels per acre less than Clark 63 in the absence of the cyst nematode. Consider Custer only where the soybean cyst nematode is present.

Kent is a rather late variety over much of Illinois, but in the southern quarter of the state it ripens at the same time as the earlier varieties do farther north. It has been a top-yielding variety in the southern quarter. It has excellent lodging resistance, but in some years it has a tendency to shatter when it is not harvested immediately after ripening.

Delmar was released in Delaware and Maryland. It is similar to Kent in maturity and shows some advantage in seed quality, but usually yields less than Clark 63 and Kent. It is resistant to root-knot nematode, which is a major problem in some states but has been of minor importance in Illinois.

Scott is recommended in southeastern Missouri and matures at about the same time as Kent. It has shown no advantage over Kent in Illinois tests.

Maturity Group V

Dare is a 1965 release and was increased by certified seed growers in Missouri, Oklahoma, Maryland, Virginia, and North Carolina. It has had limited testing in the southern tip of Illinois and has performed very well. It is suggested for growing in that area whenever a late variety is desired because it has outyielded Hill, Ogden, and Lee, and it does not have the poor seed quality of the Group IV varieties. It has moderate resistance to phytophthora root rot.

Dyer is an early maturing variety in Group V that was released in 1967 by the USDA and agricultural experiment stations of Mississippi and Tennessee. It is resistant to soybean cyst nematode, two root-knot nematodes, bacterial pustule, wildfire, and target spot. It is more susceptible to phytophthora root rot than Hill, but less shatter resistant than Hill. Dyer has yielded slightly less than Hill in the absence of soybean cyst nematode.

Hill is a late-maturing variety that has been grown on a relatively small acreage in the bottomlands in extreme southern Illinois. It will probably be replaced by the more productive Dare. Other late-maturing varieties that should be replaced by Dare in this extreme southern tip of the state include extremely late-maturing varieties such as Ogden, Hood, and Lee.

Parentage, maturity comparisons, and characteristics of most of these varieties are shown in Tables 8, 9, and 10. Yield records of many of these varieties at various locations are shown in Table 11.

Fertilizing Soybeans

Farm magazines in recent years have reported some fantastic soybean yields from contest winners. Since most contestants fertilize their contest acres irrespective of soil test levels, it is easy to gain the impression that the high yields are a direct result of applying extra fertilizer. The Agronomy Department of the University of Illinois has conducted extensive research on very high rates of N, P, and K. Before examining some of the results, here is a review of current suggestions for liming and fertilizing soybeans.

Lime. Soybeans have the same pH requirements as corn. So a goal of 6.0 or slightly above is reasonable for a soybeans-corn, cash-grain system and a goal of pH 6.5 is advised for a cropping system that includes alfalfa or clover.

Phosphorus and potassium. Soybeans give a large response to direct fertilization on soils that test low in phosphorus and potassium. Response to phosphorus on a very low-testing ($P_1 = 5$), dark prairie soil showed average 1967 to 1969 yields to be as follows: 25 bushels per acre with no fertilization; 52 bushels from 30 pounds of P_2O_5 (13 pounds of P); 54 bushels from 60 pounds of P_2O_5 (26 pounds of P); and 55 bushels from 90 pounds of P_2O_5 (39 pounds of P). These amounts of fertilizer were applied each year.

Broadcasting amounts indicated by soil tests is the preferred method in most cases. Row fertilizer is suggested where a farmer has a one-year lease or is extremely short on credit and must invest the minimum amount in fertilizer on a year-to-year basis.

Place row-applied fertilizer at least 1½ inches to the side and slightly below the seed level. "Pop-up" fertilizer, which involves a small amount in direct contact with corn seed, is unsafe for soybeans. In research plots at Dixon Springs, George McKibben cut the stand to one-half by applying 50 pounds of 7-28-14 and to one-fifth with 100 pounds.

Research has shown clearly that soybeans can feed efficiently on soil fertility that was built up for preceding crops and that they do not need direct fertilization where fertility is high.

Manganese. Manganese deficiency (stunted plants with green veins in yellow or whitish leaves) is common on high-pH, (alkaline), sandy soils, especially during cool, wet weather in late May and June. Suggested treatment is to spray 10 pounds of manganese sulfate (containing 2.5 pounds of manganese) per acre in 25 gallons of water when the beans are 6 to 10 inches tall. If the spray is directed on the row the rate can be cut in half. Some fertilizer dealers have other manganese formulations that you can apply according to instructions. Broadcast application on the soil is ineffective because the manganese becomes unavailable in soils with high pH.

Iron. Wayne and Hark soybean varieties often show iron deficiency on soils with a very high pH (usually 7.4 to 8.0). The symptoms look like manganese deficiency. Most of the observed deficiencies have been on Harpster, a "shelly" soil that occurs in low spots in some fields in central and northern Illinois. This problem appeared on Illinois farms only since the Wayne variety was introduced in 1964.

Soybeans often outgrow the stunted, yellow appearance of iron shortage. As a result it has been difficult to measure yield losses or decide whether or how to treat affected areas. Sampling by U.S. Department of Agriculture scientists in 1967 indicated yield reductions of 30 to 50 percent in the center of severely affected spots. The yield loss may have been caused by other soil factors associated with very high pH and poor drainage rather than by iron deficiency itself. Several iron treatments were ineffective in trials near Champaign and DeKalb in 1968. Minnesota, which has had far more experience than Illinois with iron deficiences, reports that "there is no known solution as yet."

In summary, the same pH, P_1, and K soil tests are suggested for corn and soybeans. Maintenance or buildup applications may be made ahead of either corn or soybeans. No nitrogen is recommended for soybeans. Sideband placement of fertilizer is suggested for certain situations, but "pop-up" applications are discouraged. Manganese should be applied on some high-pH sands. Iron treatment is not well worked out.

Results of extra high fertilization. Several experiments have been conducted in Illinois on extra heavy applications of fertilizer on soil that was already high according to soil tests.

Here are some typical results:

A. Direct fertilization (Table 12).

Table 12. — Soybean Yields From Broadcast Applications of Fertilizer; Soil Tests Before Treatment Were: pH 5.9, P_1 90, and K 285; South Farm, Urbana, Illinois, 1965

N	P_2O_5 (P)	K_2O (K)	Bushels per acre
0	0	0	57.1
0	75(33)	75(60)	55.7
0	150(65)	150(120)	58.5
75	75(33)	75(60)	56.8
150	150(65)	150(120)	56.1
300	300(131)	300(240)	57.2

The differences are small and appear to be unrelated to fertilizer added, since the average of all treated plots is slightly below the untreated-plot yield.

B. Combination of fresh and residual fertilizer and manure (Table 13).

Table 13. — Soybean Yields From 7-Year Fertility Plots With and Without Fresh Application, South Farm, Urbana, Illinois, 1968

Treatment	Bushels per acre
None	56.4
40 tons of manure and 500 lb. N, 250 P_2O_5 (K_2O each year for 7 years)	54.3
Same as 2, plus 0-250-250 in 1968	52.6
Same as 2, plus 250-250-250 in 1968	57.8

There is no consistent effect of extra fertility. Treatment 4 appears to be slightly better than untreated plot No. 1, but this is offset by apparent reductions for treatments 2 and 3. This is typical variability encountered in field trials. The results are interpreted as no response to extra high fertility, either fresh or residual. Soil test on plots 2, 3, and 4 were extremely high, with P_1 testing from 225 to 408 and K testing from 558 to 1,086.

C. Row fertilizer and localized lime (Table 14).

Table 14. — Soybean Yields From Row Applications of Fertilizer and Lime; Phosphorus (P = 40) and Potassium (K = 300) Tests Were at Suggested Levels and pH Was Slightly Low (5.8); South Farm, Urbana, Illinois, 1965

Treatment	Bushels per acre
None	59.1
200 lb. 6-24-24 (2 in. side, 2 in. below)	56.3
250 lb. hydrated lime	56.9
200 lb. 6-24-24 and 250 lb. hydrated lime	58.1
200 lb. 6-24-24 and 250 lb. fine limestone	59.4

There was no increase from fertilizer or lime or a combination of the two. The apparent reductions for some treatments are probably normal field variations.

D. Other high-fertility treatments.

Many other experiments on heavy fertilization have been conducted by Illinois agronomists: nitrogen rates up to 1,400 pounds; nitrogen sidedressing up to 200 pounds at two growth stages; manure up to 80 tons per acre for six years with and without 160-60-60; and subirrigation with a nutrient solution each week.

The results of these experiments support the fertility suggestions for soybeans that were outlined at the beginning of this review.

WHEAT

The 1968-69 Season

The 1968-69 wheat crop was planted on time, made good growth in the fall, and was favored by a winter in which very little winter injury occurred.

The state average yield of 37.5 bushels per acre was 3.5 bushels an acre below the record of 41.0 in 1966. At one time the crop looked better than this. Excessive lodging and rain that delayed harvesting in some sections contributed to the decline.

Seeds of two new soft red varieties and one hard red winter wheat variety were available for planting in the fall of 1969. The soft varieties were Timwin (developed at the University of Wisconsin) and Arthur (from Purdue University). The hard wheat variety is Parker, which was developed at Kansas State University.

There was also an import from the Southeastern United States, named Blueboy. Blueboy was grown commercially in the state in 1969, and was entered in the University of Illinois variety trials and the county extension demonstration plots for the first time.

Timwin is a very winter-hardy, short, stiff-strawed variety that matures 3 to 5 days later than Monon and Benhur. It has good tolerance to the rusts, but is susceptible to loose smut and Hessian fly. The weight per bushel is usually 3 or 4 pounds below that of Monon and Benhur.

Arthur has a good performance record in Illinois. It is a short, stiff-strawed variety comparable to Monon. It matures 1 to 2 days later than Benhur. Arthur is susceptible to one race of Hessian fly, but has good tolerance to stem rust, loose smut, soil-borne mosaic, and powdery mildew.

Blueboy is a short, stiff-strawed variety developed at North Carolina State University. It matures 7 to 8 days later than Monon and Benhur, weighs 3 to 4 pounds less per bushel than they do, and is susceptible to the rusts and Hessian fly. Blueboy is apparently more winter-hardy than most varieties developed for the Southeastern United States. However, its winter-hardiness under Illinois conditions is still to be determined, because the 1968-69 winter was relatively mild. All wheat varieties overwintered in good condition.

Blueboy had an outstanding yield record in 1969. In addition, it has good straw strength. The unanswered questions under Illinois conditions are: (1) that of winter-hardiness; (2) whether the combination of lateness of maturity and disease susceptibility may lead to serious losses in some years; and (3) whether farmers, elevators, and millers will accept the lighter weight per bushel.

Parker, the new hard red variety, shows promise for Illinois. It is shorter and earlier in maturity than Gage and Pawnee and superior to those varieties in straw strength. Parker is more resistant to lodging than any other hard wheat now being grown in Illinois. It has good tolerance to leaf rust, but is susceptible to stem rust and loose smut. Its reaction to soil-borne mosaic is about like Pawnee. It is at least comparable (if not better in performance) to other hard wheat being grown in Illinois.

Table 15. — Yield Record of Leading Wheat Varieties in Agronomy Department Tests at Brownstown, Urbana, and DeKalb

	Brownstown		Urbana		DeKalb	
	1969	1968-1969 average	1969	1968-1969 average	1969	1968-1969 average
	Bushels per acre					
Soft Wheat						
Arthur	60	54	70	65	72	62
Benhur	56	50	70	63	64	56
Blueboy	74		81		68	
Knox 62	54	50	61	57	63	55
Monon	51	49	66	62	68	62
Riley	50	48	62	60	68	56
Stadler	54	51	66	64	69	62
Timwin	51	49	77		72	66
Vermillion	57	52	64	62	72	63
Hard Wheat						
Gage	41	43	61	56	62	52
Guide	47	46	66	55	63	53
Ottawa			59	50		
Parker	50	48	64	60	65	58
Pawnee	44	44	58	50	54	51
Scout 66	47	45	67	58	59	51
Triumph	49	48	62	49	55	43

Varieties: Hard Red Winter

Ottawa is a red chaff variety released in Kansas in 1960. It is similar to Pawnee in yield and maturity, but it has better grain quality and improved straw strength. It is resistant to stem rust but is susceptible to loose smut, which could become a problem. Ottawa has an excellent yield record in Illinois yield trials and on Illinois farms. Though its chaff color is principally red, it normally has a small number of white chaff heads and certain environmental conditions can increase this number.

Gage, released by Nebraska in 1963, appears to be well adapted to Illinois. Similar to Pawnee in maturity and straw strength, it has improved resistance to rust, Hessian fly, and soil-borne mosaic. Gage has performed well in Illinois trials, generally outyielding both Pawnee and Ottawa by several bushels per acre. Its only weakness is poor straw strength. It is comparable to Pawnee in straw strength.

Scout, a 1964 release from Nebraska, has yielded well in Illinois trials. It is similar to Gage in maturity, straw height, and strength. It is susceptible to soil-borne mosaic and leaf rust.

Scout 66 is an improved version of Scout, being more

Table 16. — 1969 Wheat Variety Demonstration Yields (Bushels per Acre), Hard Wheat Varieties

County or location	Gage		Guide		Improved Triumph		Ottawa		Parker		Pawnee		Scout 66	
	Bu./A.[a]	T.W.[b]	Bu./A.	T.W.	Bu./A.	T.W.	Bu./A.	T.W.	Bu./A.	T.W.	Bu./A.	T.W.	Bu./A.	T.W.
Belleville	42.8	56.5	40.1	56.0	45.5	57.1	34.8	56.9	44.9	59.0	34.6	55.7	37.1	55.9
Dixon Springs	39.5	55.0	37.8	55.5	47.3	56.5	40.0	57.4	49.7	59.1	36.3	56.7	44.9	57.4
Oake's Farm	50.0	57.0			56.7	57.0	46.7	57.0	63.3	59.0				
Macoupin	62.0	54.0	61.0	61.0	52.6	55.0	48.6	54.0	66.2	58.0	59.5	56.0	63.2	56.0
Monroe	51.0	56.6	44.0	55.0	48.0	56.4	50.0	55.4	50.0	59.0	50.0	53.8	51.0	54.3
Perry	21.0	55.5	19.1	56.0	25.4	55.0	22.3	56.0	23.8	57.0	21.7	56.0	26.8	54.5
St. Clair	39.4	54.0	45.9	54.6	44.0	54.2	39.7	55.0	36.9	55.0	40.4	54.5	43.3	53.3
St. Clair	60.4	56.0	51.0	56.0	48.6	56.5	52.9	56.0	54.1	58.5	50.0	55.5	51.4	56.5
Schuyler	58.7	57.5	59.8	57.0	58.6	56.0	54.9	58.0	60.6	58.0	48.6	57.0	61.4	57.0
Shelby	45.1				51.1		47.5	57.4	57.4		44.8		51.8	
Average for eight of the locations	47.0	56.0	45.0	57.0	46.0	56.0	43.0	56.0	48.0	58.0	43.0	56.0	47.0	56.0

[a] Bu./A. = bushels per acre.
[b] T.W. = test weight.

uniform in height and maturity and higher in milling and baking qualities. Scout and Scout 66 are early maturing and are adapted to a wide climatic range.

Varieties: Soft Red Winter

Arthur is a 1967 release by the Purdue Agricultural Experiment Station and the USDA. It has been a high-yielding variety in Illinois tests with excellent test weight. It is as winter hardy as Monon, is beardless, white chaffed, and early maturing, and has a short, stiff straw. Arthur responds well to high fertility. It is moderately resistant to leaf rust, and has good resistance to stem rust, powdery mildew, loose smut, soil-borne mosaic, and race A of the Hessian fly.

Benhur looks very promising for the soft wheat growing section. It was released in 1966 by the USDA and was developed at Purdue University. It is a white chaff, beardless variety that matures 1 to 2 days earlier than Monon and under some conditions is as much as 3 inches shorter. It is superior to Monon in leaf and stem rust, Hessian fly, and lodging resistance. Yields of Benhur have been high in Illinois. Under some conditions the chaff and stems may turn dark in color. This tendency, which is inherited from one of its parents, does not affect its yield.

Monon, a beardless white chaff variety, was released by Purdue in 1959. It grows 2 or 3 inches shorter than Knox and matures about 1 day earlier. It has more lodging resistance than Knox and Vermillion and is equal to Vermillion and better than Knox in winter hardiness. Monon is resistant to soil-borne mosaic and moderately resistant to Hessian fly and leaf rust. It is susceptible to stem rust, loose smut, and bunt. In the mature-plant stage, it is moderately resistant to powdery mildew.

Riley is a white chaff, soft red wheat. It was released by Purdue in 1965. It is short, like Monon, and about 2 days later in maturity, but offers greater straw strength than Monon or Knox 62. Riley is resistant to the loose smut and soil-borne mosaic. It is moderately susceptible to powdery mildew, leaf rust, and Hessian fly.

Riley 67 was developed by Purdue and is comparable to Riley in all characteristics, except it is superior in leaf-rust resistance.

Varieties: Hard Red Spring

Hard red spring wheat is usually lower yielding than hard red winter or soft red winter wheat varieties. Spring wheat production should be limited to the very northern part of Illinois. Hard red spring wheats are vulnerable to the fungus disease Scab, to insects like Hessian fly, and chinch bugs, and to hot dry weather. Early planting on a good seedbed with treated seed helps avoid these problems.

Damage depends on the environment, especially the temperature and moisture relationship during heading and early seed development. Spring wheat should not follow a cereal crop unless all residues, stalks, and straw are completely covered when plowing. Scab not only reduces the yield of the grain, but also seriously lowers market quality and feeding value. Hessian fly or chinch bugs, or both, can be a serious threat if spring wheat follows or is close to an infested wheat field. Hot and dry weather can force it into maturity too early and thus reduce yield and weight per bushel.

Selkirk was developed in Canada. It is beardless, has white chaff, and is medium in maturity and straw strength. It is moderately resistant to leaf rust; is resistant to stem rust, bunt, and loose smut; and produces a good yield of high-quality grain. It is suggested for planting because of good straw strength and disease resistance.

Table 17. — 1969 Wheat Variety Demonstration Yields (Bushels per Acre), Soft Wheat Varieties

County or location	Arthur		Benhur		Blueboy		Knox 62		Monon		Riley		Stadler		Timwin	
	Bu./A.[a]	T.W.[b]	Bu./A.	T.W.	Bu./A.	T.W.	Bu./A.	T.W.	Bu./A.	T.W.	Bu./A.	T.W.	Bu./A.	T.W.	Bu./A.	T.W.
Belleville	46.6	57.2	44.1	56.9	58.6	52.8	40.2	56.9	40.8	55.5	45.6	55.6	35.7	56.0	39.4	52.6
Dixon Springs...	62.5	57.8	48.5	57.1	69.9	53.1	50.0	56.7	50.6	56.0	51.6	55.1	45.2	55.2	45.5	51.6
Newton........	57.4		49.7		67.7		56.6		51.0		51.5		52.3		50.3	
Gallatin.......	60.8		69.1		87.7		69.3		62.8		68.5		69.8		58.6	
Hamilton.......	37.1	59.0	30.0	59.0	47.5	59.0	36.6	59.0	21.4	57.5	38.6	59.5	35.3	60.0	28.4	59.0
Hamilton.......	30.1	58.0	31.5	57.0	49.4	57.0	34.2	58.0	26.9	57.0	33.3	56.0	28.9	57.0	24.7	56.0
Macoupin......	63.4	59.0	57.2	59.0	50.0	57.0	52.0	57.0	60.8	57.0	68.4	56.0	63.2	55.0	52.2	57.0
Monroe........	50.0	57.0	47.0	56.2	71.0	54.6	50.0	57.5	50.0	56.3	47.0	55.6	53.0	57.1	50.0	55.0
Perry..........	31.4	55.0	34.8	57.0	38.5	55.0	41.3	55.0	35.3	55.0	30.5	55.0	31.8	56.0	32.4	56.0
St. Clair........	56.2	54.1	44.9	54.5	64.5	54.5	49.7	54.3	48.6	53.5	46.0	55.0	51.2	53.1	44.3	52.0
St. Clair........	66.1	56.5	56.7	56.5	71.4	53.0	50.2	56.0	56.4	56.0	55.0	53.0	55.5	54.0	57.7	54.0
Saline..........	37.8	57.0	34.9	54.0	39.5	53.0	16.8	55.0	29.4	56.0	30.2	54.0	32.2	57.0	17.5	53.0
Schuyler........	77.8	57.0	74.1	57.5	81.0	56.0	62.7	57.0	64.0	56.5	61.4	57.0	57.7	57.0	77.7	57.0
Shelby.........	63.1		62.6				52.6		61.4		52.2		54.0			
Wabash........	51.4	58.0	46.8	58.0	40.6	57.0	43.3	58.0	42.2	56.0	61.8	54.0	45.8	58.0	56.1	
Average for 14 of the locations..	52.0	57.0	48.0	57.0	60.0	55.0	47.0	57.0	46.0	56.0	50.0	56.0	47.0	56.0	45.0	55.0

[a] Bu./A. = bushels per acre.
[b] T.W. = test weight.

Table 18. — Hard Red Spring Wheat Variety Yields at DeKalb, Illinois

	Bushels per acre		Pounds per bushel	
	1969	1968–1969 average	1969	1969–1968 average
Chris................	30	58	58	57
Crim................	30	57	57	56
Justin...............	28	58	57	58
Lathrop.............	34	59	59	59
Pembina.............	34	57	57	56
Selkirk..............	30	56	55	54

Pembina, released in Canada, is an early variety. It is beardless, has white chaff, and is rust resistant.

Chris is a beardless hard red spring wheat of medium height and maturity with moderately stiff straw. It is resistant to prevalent races of stem rust, leaf rust, and black chaff. It has good test weight and satisfactory milling and baking qualities. It was released by Minnesota in 1965.

Crim, released in Minnesota in 1963, is resistant to stem rust but susceptible to leaf rust and loose smut. Its grain quality is satisfactory.

Table 19. — Applications of Available Phosphorus for Wheat (P_2O_5 and Equivalent Pounds P)

P_1 test level	Percent of possible yield	Pounds of P_2O_5 or P to be added per acre based on the P_1 test					
		P_2O_5			P		
		Broadcast		Through planter or drill	Broadcast		Through planter or drill
10–15......................	Below 47	90[a] to 150[a]	+ or	30 90[a]	39[a] to 65[a]	+ or	13 39[a]
20........................	57	60 to 120[a]	+ or	30 80	26 to 53[a]	+ or	13 35
30........................	72	60 to 90[a]	or	60	26 to 39[a]	or	26
40........................	82	60	or	30 to 60	26 or 13 to 26		
60........................	92			30	13		

[a] The soil test will likely increase about 1 pound for every 9 pounds of P_2O_5 fertilizer (4 pounds of P) applied. Rates of 120 and 150 pounds are for those who desire a rapid buildup in available phosphorus and for all fields on which alfalfa, clover, or lespedeza will be seeded unless the P_1 test is already 50 or above.

Table 20. — Total Nitrogen Applications (Fall Plus Spring) for Different Soil Situations and Varieties

Soil situation	For fields with alfalfa or clover seedings (pounds)		For fields with no alfalfa or clover (pounds)	
	Benhur Riley	Other adapted varieties	Benhur Riley	Other adapted varieties
Soils **low** in capacity to supply nitrogen: inherently low in organic matter (light colored), no manure, alfalfa, or clover in the preceding year	50–70	40–60	70–90	50–70
Soils **medium** in capacity to supply nitrogen (compare situation to **low** above and **high** below)	30–50	20–40	50–70	30–50
Soils **high** in capacity to supply nitrogen (light-colored soils that regularly have legumes or manure and all deep, dark-colored soils)	20–30	0	40–50	20–30

Justin, released in North Dakota in 1962, is a hard red spring wheat with good milling quality. It is resistant to strain 15B stem rust and to black chaff. Yields have been slightly lower than some of the other varieties.

Lathrop, a 1961 Wisconsin release, is similar to Henry, and also has fly resistance. *Lathrop is a feed wheat.*

Fertilizing Wheat

Among Illinois field crops wheat is second only to corn in response to fertilizer.

Phosphorus. Wheat requires a large amount of *readily available phosphorus* in the fall. Phosphorus stimulates early growth, promotes winter survival, and helps make the young plant capable of high yield in the following year.

Suggested applications of phosphorus-supplying fertilizer for wheat in Illinois given in Table 19 are based on P_1 soil tests.

If you do not have the results of a P_1 soil test, apply 30 to 60 pounds of available P_2O_5 (13 to 26 pounds P) through the drill or broadcast about 60 to 120 pounds (26 to 53 pounds P). The lower figure in both cases is for fields on which considerable phosphorus has previously been added.

The Department of Agronomy at the University of Illinois has revised the interpretation of the P_1 test for corn based upon the available phosphorus in the subsoil, but the interpretation of the test for wheat will be the same for all soils until new data show that a change should be made.

Nitrogen. The nitrogen fertilizer program affects not only the profit from the wheat crop, but also the stand of alfalfa or clover that is seeded in the wheat (Table 20).

Wheat will usually respond to extra nitrogen up to the point where lodging begins. Greatest increases for nitrogen are on light-colored forest soils (formed under native cover of trees rather than prairie grasses). The light-colored prairie soils of south central Illinois are also relatively low in organic matter and thus respond well to nitrogen. Coarse-textured soils (sands, sandy loams, and gravelly loams) generally need extra nitrogen because nitrates leach readily from the root zone in these soils.

Fall application. The amount of nitrogen needed for good fall growth is not large because the total uptake in roots and tops is not likely to exceed 30 to 40 pounds per acre. The suggested rate for applying nitrogen in a mixed fertilizer through the drill on light-colored soils is therefore only 15 to 20 pounds. The safe upper limit for N plus K is about 40 pounds per acre.

On dark-colored soils nitrogen is not needed at planting time.

Potassium. Wheat is not very responsive to potassium unless the soil test is below 100. The potassium fertilizer applied before planting or at planting time is therefore aimed mainly at meeting the needs of the forage legume to be seeded in the wheat or as part of a general soil buildup or maintenance treatment.

BARLEY

Barley acreage in Illinois had been declining in recent years including the 1969 crop. There were 17,000 acres of barley harvested in 1969 compared with 19,000 in 1968. The average yield was 40 bushels per acre in 1969 and 44 bushels per acre in 1968.

The 1968-69 season for winter barley was generally favorable in central Illinois. There was severe lodging in many areas of southern Illinois.

The 1969 season for spring barley was less than favorable, resulting in severe lodging in central and northern Illinois. The performance of spring and winter barley varieties is shown in Tables 21 and 22.

Table 21. — Spring Barley Performance at Urbana and DeKalb, Illinois

	Urbana		DeKalb	
	Bushels per acre		Bushels per acre	
	1969	1968-69	1969	1968-69
Conquest	52	48	61	60
Dickson	52	60	53	55
Larker	50	56	62	56
Primus	63	70	68	60
Traill	57	58	68	65

Table 22. — Winter Barley Performance at Urbana and Brownstown, Illinois

	Urbana		Brownstown	
	Bushels per acre		Bushels per acre	
	1969	1968-69	1969	1968-69
Barsoy	44	58	40	46
Harrison	59	74	59	50
Hudson	77	80	51	46
Jefferson	55	67	34	39
Lakeland	76	93	67	56
Will	69	77	49	55

SPRING OATS

The 1969 Season

The 1969 oat crop started the season in good condition and looked as if it would equal the record yield of 1968. Excessive rains, especially in northern Illinois, delayed harvest and aggravated an already serious lodging problem in some areas.

Average yield was estimated to be 62 bushels per acre, which is 4 bushels below the 1968 record.

To shoot for top returns from spring oats follow these steps:

1. Select a top variety.
2. Sow only high-quality seed. Certified seed is a good guarantee that you will get what you pay for.
3. Plant treated seed. In addition to controlling smut, treated seed will usually yield 3 or more bushels per acre higher than non-treated.
4. Prepare a good seedbed. Once over with a disk won't bury heavy cornstalks. Plowing is best, but if that is not practical shred your stalks and disk well. See page 45 for tillage practices.
5. Fertilize. Oats respond to nitrogen and soluble phosphorus. See page 25 for a discussion of the fertilization of oats.
6. Plant early, as soon as you can get the land ready.
7. Use a drill. Drilled oats produce 7 to 10 bushels per acre more than broadcast.

Varieties

Kota was developed by South Dakota State University. It is similar to Portal in height, heading date, maturity date, test weight, and kernel size. It is moderately resistant to lodging and to stem and crown rust. It is resistant to smut and has some tolerance to the barley yellow dwarf disease (BYDV).

Jaycee is an early maturing, high-yielding variety developed at the University of Illinois. The grain color is light brownish to yellowish white. It produces fairly large, plump kernels with groat percentage and test weight similar to Newton. Jaycee is very short strawed (1 to 3 inches shorter than Goodfield), and has stood well under Illinois conditions until maturity. Jaycee loses its strength rapidly after maturity. Harvest Jaycee as soon after maturity as is possible to avoid high field losses. It has barley yellow dwarf virus tolerance that is superior to any variety now available for growing in Illinois. It is resistant to some, but not all, races of leaf and stem rust. Jaycee is resistant to races of smut that have occurred in Illinois.

Tyler, developed at Purdue, is similar to Goodfield and Tippecanoe in height and standing ability, but has been superior to both in yield. Tyler matures approximately 2 days earlier than Clintland 60. The grain is a light brownish white (or light yellow in some seasons), plump, and medium in test weight. Tyler resists some races of leaf rust as well as the current races of stem rust. It is susceptible to smut, so the seed should be treated with an appropriate chemical before seeding to control the smuts. Tyler is susceptible to BYDV. Because of its short, stiff straw and generally high-yielding ability, it should respond well to high fertility levels.

Clintford also was developed at Purdue from the cross

Table 23. — 1969 County Oat Variety Demonstration Yields (Bushels per Acre)

County	Brave	Clint-ford	Clint-ford 64	Garland	Holden	Jaycee	Newton	Orbit	Pettis	Portal	Tyler
Boone	76	83	85	80	80	83	56	87	83	87	81
Bureau	45	70	65	75	67	60	..	68	..	60	87
Ford	38	32	18	28	21	54	31	37	27	21	33
Henderson	..	77	92	85	85	96	59	79	67	82	94
Jo Daviess	92	89	107	89	101	77	81	82	93	106	92
Knox	86	82	73	79	83	95	76	81	88	81	85
Lake	116	79	65	68	73	72	86	74	95	79	85
Mercer	52	100	86	74	81	106	67	64	79	72	95
Stark	72	91	78	73	73	98	78	92	..	79	92
Stephenson	61	75	59	63	62	63	71	57	69	59	54
Warren	90	113	95	95	79	113	122	85	100	62	89
Winnebago	57	73	80	66	60	66	60	69	42	69	60
Ave. of 11 of the locations	71	81	73	72	71	81	..	72	..	70	77
Ave. of 12 of the locations	..	80	75	73	72	83	71[a]	73	74[a]	71	79

[a] Average of all locations, but not directly comparable to other averages.

of a Clintland type with Milford. Milford was introduced from Wales for its excellent straw strength. Clintford is the first variety in the United States to use this source of straw strength. The grain is a light brownish white (or light yellowish white in some seasons), large, plump, and very high in test weight. Clintford has very short, stiff straw with large-diameter stems. It matures about 2 days earlier than Clintland. Clintford has a compact panicle that distinguishes it from other varieties grown in Illinois. Its reactions to leaf and stem rusts are equal to those of Clintland, but inferior to Clintland 60 or Clintland 64. Clintford is resistant to most races of smut, shows some tolerance to BYDV, and is moderately susceptible to Septoria. Because of its short, stiff straw and relatively high-yielding ability, Clintford should respond well to high fertility levels.

Brave is a high-yielding variety from Illinois. It has excellent smut resistance, some tolerance to Septoria, and tolerance to BYDV. Its test weight is adequate, quality good, and seed color yellow. Brave has fair straw strength but is not quite equal to Newton in this respect. Generally an early variety, Brave appears to be well adapted throughout Illinois.

Clintland 64 was released by the Indiana Agricultural Experiment Station and is very similar to Clintland 60, except for improved leaf-rust resistance. Clintland 64 is one of the most leaf-rust-resistant varieties currently available. The variety is not resistant to BYDV.

Orbit is a recent white-oat release from Cornell University. It is short-strawed, lodging resistant, and matures three to five days later than Newton. It is resistant to smut, stem rusts, and some of the leaf rusts. Orbit has about the thickest hull among current varieties. The heavy hulls lower the groat-to-hull percentage.

Garland, released by Wisconsin, performs very well in northern and central Illinois. A sister selection of Dodge and Goodfield, Garland has shown top performance both in Urbana and DeKalb yield trials and in county demonstrations. It has good test weight, stands well, and has resistance to some races of smut.

Newton was released by Indiana in 1955. This variety has both Nemaha and Clinton in its parentage, and combines the best characteristics of each. Generally, it has large, plump kernels and good straw strength. Newton shows some tolerance to yellow dwarf and has some rust resistance, but it is susceptible to several of the newer races of rust. It is also susceptible to Septoria.

Holden was released by the Wisconsin Agricultural Experiment Station in 1967. The variety matures slightly later than Garland. Its yield has been 5 to 8 percent greater per acre than Garland. The grain of Holden has a yellow hull, a well-filled kernel, and a good test weight that is equal to Garland. Holden is resistant to older races of leaf rust and intermediate-to-susceptible to newer races. It has resistance to smut and some races of stem rust.

Portal was released by the Wisconsin Agricultural Experiment Station in 1967, and is a variety that matures in midseason in Illinois. Portal is similar to Garland in most characteristics but has yielded 5 to 10 percent more than Garland. The test weight and straw strength of Portal are slightly less than Garland. It is taller than Garland and matures a little later than Garland. The variety has a yellow hull and resistance to smut and most races of stem rust. Portal has more resistance to leaf rust than most varieties available at present, equaling Clintland 64.

Pettis was released by the Missouri Agricultural Experiment Station in 1967. The variety is early maturing in Illinois, and has a high test weight and high groat percentage. Pettis has excellent tolerance to BYDV and some races of stem rust. The seeds of the variety are red and

Table 24. — University of Illinois Oat Variety Yields

Variety	DeKalb			Urbana			Brownstown		
	1969		1968–1969 average	1969		1968–1969 average	1969		1968–1969 average
	Bu./A.[a]	T.W.[b]	Bu./A.	Bu./A.	T.W.	Bu./A.	Bu./A.	T.W.	Bu./A.
Brave	72	29	94	66	30	88	66	33	88
Clintford	71	31	94	53	31	75	49	32	68
Clintford 64	66	29	92	51	27	77	54	34	..
Garland	78	30	101	62	28	80	52	34	71
Holden	77	30	102	60	27	87	53	34	76
Jaycee	84	28	106	81	33	95	60	33	84
Kota	87	29	..	78	29	..	..	..	..
Newton	70	28	98	69	31	87	54	30	76
Orbit	76	29	104	65	27	92	64	36	83
Pettis	77	30	102	77	34	..	63	35	..
Portal	80	30	103	50	26	77	44	32	72
Tyler	67	29	97	63	28	82	48	28	69

[a] Bu./A. = bushels per acre.
[b] T.W. = test weight.

moderately small. The straw is 1 inch shorter and slightly weaker than the variety Mo. 0-205. It has weaker straw than most varieties currently grown in Illinois.

The results of the 1969 county oat variety demonstrations and the University of Illinois yield trials are found in Tables 23 and 24. It is usually unwise to make a choice of a variety based on just one year's data at one location or the results of only one county demonstration. It is better to base decisions on the average results of two or more years.

Fertilizing Oats

Since an oat field usually has a forage seeding in it, the fertilizer application must be planned to meet the needs of both crops. Both have high phosphorus requirements. Suggested treatments are slightly lower than for wheat (Table 19, page 21), because oats are less valuable than wheat.

Oats have a relatively low potassium requirement, so plan the application to meet the needs of the legume seeding or to build up the soil-test level (Table 33, page 40), or both.

A large proportion of Illinois oat fields would benefit from nitrogen fertilizers. Varieties have become progressively shorter, with stiffer straw, so they resist lodging and give a yield increase with higher rates of nitrogen.

On highly fertile, dark-colored soils in livestock systems of farming where lodging is still likely, no extra nitrogen is suggested. In typical situations in central and northern Illinois, use 40 to 60 pounds. On light-colored soils that have not regularly had either legume crops or manure, 80 pounds of nitrogen is about right.

In all fields where you make a legume seeding, apply slightly less nitrogen than is normally recommended for the oats. This will improve the seeding more than enough to offset the reduction in oat yield.

HAY, SILAGE, AND PASTURE

The 1969 Season

Excess moisture in the spring and throughout the harvesting period for first- and second-cutting hay was the general situation in northern and southern Illinois. Early season rains delayed some spring seedings. Rains through May prevented timely application of herbicides on some seedings made in April and early May. Much of the first-cutting hay was not made or was rained on. Delays in first and second cuttings prevented some third cuttings from being made.

Pastures made good growth and provided a large amount of feed. Pasture conditions were generally very good throughout the season. More pasture was available than needed in many areas.

Alfalfa weevil continued to be a problem. Control with insecticides has been effective. Southern Illinois farmers had damage on the first-cutting hay, requiring one foliage spraying and one stubble spraying after removal of the first cutting. Central Illinois farmers had very little damage on first-cutting alfalfa, but needed stubble spray after the first cutting. Damage was light in northern Illinois and little spraying for weevils was needed. Natural parasites have been helpful in reducing the alfalfa weevil problem. Cool springs also delay weevil development.

Hay acreage in 1969 declined 26,000 acres from 1968, with alfalfa acreage reduction accounting for 16,000 fewer acres (Table 25).

Table 25. — Hay Acreage and Yields in Illinois[a]

Year	Alfalfa (thousands of acres)	Alfalfa yield (tons per acre)	All hay (thousands of acres)	Hay yields (tons per acre)
1963	1,117	2.60	1,961	2.17
1964	1,128	2.75	1,896	2.28
1965	1,064	2.90	1,744	2.44
1966	939	2.80	1,552	2.38
1967	869	3.20	1,409	2.70
1968	782	3.25	1,305	2.73
1969[b]	766	3.10	1,279	2.64

[a] Bul. 68-1, Ill. Coop. Rept. Serv.
[b] Preliminary estimate, Sept. 1, 1969.

Alfalfa

Low yields are major problems with the hay crops, including alfalfa. The potential yield of the crop is three or more times greater than the state average of 3.2 tons per acre. Some soil and climatic situations reduce the potential somewhat. Even on the lower potential soils, yields are one-third to one-half of easily reached potential.

Some major barriers to higher alfalfa yields are poor drainage, inadequate stands, low fertilization, late harvests, and long periods of time between harvests.

Soils with good internal drainage and slope enough for surface drainage are ideal. Poorly drained soils should be tiled if feasible and provisions should be made for surface drainage. Alfalfa stands that have surface water on them for extended periods in winter and early spring have more winter killing and winter damage, such as heaving, than where surface water is removed.

Establishment

Good stands of alfalfa are needed to produce high yields. The approximate numbers of alfalfa plants needed per square foot at the first harvest are as follows: seeding year, 30; first hay year, 10; and succeeding hay years, 5.

Seedbed preparation is a very important step in successful establishment of alfalfa. The most frequent causes for small-seeded legume and grass seeding failures are a loose seedbed and failure to firm the seed into contact with the soil after seeding. Work a plowed or heavily disked seedbed by disking and harrowing to cover most of the previous crop debris and to reduce soil particles to a size smaller than is desirable for corn, soybeans, or small grains, but do not make the soil powdery fine. Roll the seedbed with a corrugated roller unless high soil moisture conditions make this operation unwise. If you use a preplant herbicide which requires incorporation, apply the herbicide before the last disking.

Two general methods of seeding have proven very reliable: band-press seeding or broadcasting and using a corrugated roller.

The **band-press** method has an advantage over the broadcast method where soil fertility is low and perhaps where crusting is a problem. A high-phosphate-ratio fertilizer is placed by a grain drill in a band 1½ to 2 inches below the soil surface. The seed is directed onto the soil surface by means of rubber or plastic tubes from the seed hopper directly above the fertilizer band. A press wheel then rolls directly over the seed, pressing the seed into contact with the soil and covering the seed slightly. Firm the seedbed with a corrugated roller before seeding.

With seeds placed in a band over the fertilizer, the seedlings get their roots into a high-fertility zone soon after germination and make rapid growth as compared with seedlings in a low-fertility situation. If the soil tends to crust, several seeds closely placed in a band can help each other break the crust, while under a broadcast system none of the seeds is close enough together to assist each other in breaking a soil crust.

Broadcast seedings are made either with corrugated roller seeders or by firming the seedbed with a corrugated roller, then distributing the seed uniformly at random over the seedbed, and finally firming again with a corrugated roller. This method is usually successful if the soil fertility is high and seedings are made timely.

The seeding rate used will depend on the time of seeding and intended use the year of seeding. Make late-summer seedings at the rates suggested in the "Forage Seed Mixtures" list on page 28. No grazing or harvesting of these seedings is advisable during the seeding year. If you make spring seedings with a companion crop (oats or wheat) you should find the rates suggested in the seed mixtures list adequate.

If you make spring seedings without a companion crop and use herbicides you may increase the legume portion in the seed mixtures list about 50 percent. The higher seeding rate can be justified only if the crop will be harvested two or three times in the seeding year. Pure seedings of alfalfa made in the spring without a companion crop may be harvested two or three times during the seeding year in northern Illinois and three times in central and southern Illinois. A vigorous variety that recovers rapidly after harvesting can be expected to provide the greatest benefit from increasing the seeding rate by 50 percent.

For alfalfa seedings made in late summer during a drouth period, use varieties with late-fall dormancy. The early fall-dormancy varieties, such as Vernal, may go into dormancy as small weak seedlings if emergence is delayed by drouth conditions. Small seedlings suffer more winter injury than larger seedlings even though the larger seedlings may be of a variety not as winter hardy.

Seeding Mixtures

Variety mixtures of two or more varieties may have a lasting benefit if the varieties are well chosen. Non-winter-hardy varieties in mixtures with winter-hardy varieties have proven detrimental to long-term forage yields. In the mixture below, the addition of Moapa alfalfa to the seeding mixture resulted in a lower yield because the Moapa variety was not winter hardy and most of these

Seed mixture, 12 lb. per acre	Tons dry matter per acre, Urbana, 1966-67
Vernal	7.06
⅔ Vernal + ⅓ Moapa	6.92
⅓ Vernal + ⅔ Moapa	6.20
⅔ Vernal + ⅓ Stride	7.24
⅓ Vernal + ⅔ Stride	7.39

plants winter-killed the first winter after seeding. The loss of Moapa plants expressed itself in lower yield the two following years. Vernal did not have the capability to enlarge in plant size enough to fill in areas left vacant by winter-killed plants. Competition for growing space was evident among seedling plants in the seeding year, even at 12 pounds per acre seeding rate.

Moapa competed with Vernal during the establishment year, preventing the establishment of some plants and reducing seedling vigor of others. The same competition undoubtedly occurred between Vernal and Stride. The yield increase for these mixtures reflects the greater vigor and yield potential of Stride and the presence of a high population of plants of this variety in the mixtures at harvest time. There was no serious loss of Stride or Vernal to winter-kill during the two winters of the testing period. As Stride was eliminated from the aging stand by bacterial wilt, the yields of the mixtures were lower than the seedings of Vernal alone. This response has been observed in alfalfa-red clover mixtures also.

Species mixtures involving a long-lived and a short-lived species (alfalfa and red clover) have little advantage unless the short-lived species is exceptionally high yielding or has other attributes.

The yields over a two-year harvest period of alfalfa-red clover mixtures, in which alfalfa made up two-thirds of the mixture, have been slightly lower than alfalfa seeded alone, as the following yield figures indicate:

Seed mixture	Tons of hay per acre, DeKalb, 1962-63
Alfalfa	4.75
⅔ Alfalfa + ⅓ Red Clover	4.70
⅓ Alfalfa + ⅔ Red Clover	4.65
Red Clover	2.70

Species mixtures may have an advantage over single species in fields that have variable soil conditions, such as varying pH or drainage, and susceptibilities to flooding, ice sheet, and so on. For example, red clover is productive at lower soil-pH levels than alfalfa. Red clover is more tolerant of poorly drained soil conditions than alfalfa, but is more readily injured by ice sheet than alfalfa.

There is more effort spent on variety improvement with alfalfa than any other small-seeded forage crop usually grown in Illinois. New alfalfa varieties will not likely be used in mixtures with red clover because of the relatively lower yield potential of red clover. Some of the new alfalfa varieties have particular adaptations. For example, Iroquois is a bacterial-wilt-resistant, winter-hardy alfalfa variety that is better adapted to poorly drained soils than most other alfalfa varieties. Varieties such as Iroquois may be mixed with other high-yielding varieties with other specific adaptations to widen the soil and climatic adaptation range of the mixture.

Grasses added to legumes usually result in a slight yield increase during the years when the legumes make up a major part of the mixture composition. When grasses become dominant in a mixture with alfalfa or red clover, overall yields usually decline.

Management

The management objectives with legume-grass hay or pasture fields should be to maintain the legume at a high level. Rotational grazing, grazing periods not over 7 to 10 days, a recovery period of 35 to 40 days, grazing

FORAGE SEED MIXTURES

For Rotation and Permanent Pastures

Central and northern Illinois

Well-drained soils	*Pounds per acre*
Alfalfa	6 lb.
Bromegrass	5 lb.
Timothy	2 lb.
Alfalfa	6 lb.
Orchardgrass	4 lb.
Alfalfa	6 lb.
Orchardgrass	4 lb.
Timothy	2 lb.
Orchardgrass	6 lb.
Ladino clover	½ lb.
Red clover	8 lb.
Ladino clover	½ lb.
Orchardgrass	6 lb.
Red clover	8 lb.
Ladino clover	½ lb.
Tall fescue	6-8 lb.
Birdsfoot trefoil	5 lb.
Timothy	2 lb.
Bromegrass	8 lb.
Ladino clover	½ lb.
Tall fescue	10 lb.
Orchardgrass	8 lb.

Poorly drained soils	
Alsike clover	3 lb.
Ladino clover	¼ lb.
Timothy	4 lb.
Birdsfoot trefoil	5 lb.
Timothy	2 lb.
Reed canarygrass	8 lb.
Alsike clover	3 lb.
Ladino clover	¼-½ lb.
Alsike clover	2 lb.
Tall fescue	8 lb.
Ladino clover	½ lb.

Drouthy soils	
Alfalfa	6 lb.
Bromegrass	5 lb.
Alfalfa	6-8 lb.
Orchardgrass	4 lb.
Alfalfa	6-8 lb.
Tall fescue	6 lb.
Red clover	8 lb.
Ladino clover	½ lb.
Orchardgrass	6 lb.
Red clover	8 lb.
Ladino clover	½ lb.
Tall fescue	6-8 lb.

Southern Illinois

Well-drained soils	*Pounds per acre*
Alfalfa	8 lb.
Orchardgrass	4 lb.
Alfalfa	8 lb.
Tall fescue	6 lb.
Tall fescue	8 lb.
Ladino clover	½ lb.
Alfalfa	8 lb.
Bromegrass	6 lb.
Timothy	2 lb.
Orchardgrass	6 lb.
Ladino clover	½ lb.
Tall fescue	10 lb.
Orchardgrass	8 lb.
Red clover	8 lb.
Ladino clover	½ lb.
Orchardgrass	6 lb.
Red clover	8 lb.
Ladino clover	½ lb.
Tall fescue	6-8 lb.

Poorly drained soils	
Alsike clover	2 lb.
Tall fescue	8 lb.
Ladino clover	½ lb.
Reed canarygrass	8 lb.
Alsike clover	3 lb.
Ladino clover	½ lb.

Drouthy soils	
Alfalfa	8 lb.
Orchardgrass	4 lb.
Alfalfa	8 lb.
Tall fescue	6 lb.
Red clover	8 lb.
Ladino clover	½ lb.
Orchardgrass	6 lb.
Red clover	8 lb.
Ladino clover	½ lb.
Tall fescue	6-8 lb.

For Hay Crops

Central and northern Illinois

Well-drained soils	*Pounds per acre*
Alfalfa	12 lb.
Alfalfa	8 lb.
Bromegrass	6 lb.
Alfalfa	8 lb.
Bromegrass	4 lb.
Timothy	2 lb.
Alfalfa	8 lb.
Timothy	4 lb.

Poorly drained soils	
Alsike clover	5 lb.
Timothy	4 lb.
Reed canarygrass	8 lb.
Alsike clover	3 lb.
Birdsfoot trefoil	5 lb.
Timothy	2 lb.

Drouthy soils	
Alfalfa	8 lb.
Bromegrass	6 lb.
Alfalfa	8 lb.
Tall fescue (south and central Illinois only)	6 lb.

Southern Illinois

Well-drained soils	*Pounds per acre*
Alfalfa	8 lb.
Orchardgrass	6 lb.
Alfalfa	8 lb.
Tall fescue	6 lb.

Poorly drained soils	
Reed canarygrass	8 lb.
Alsike clover	4 lb.
Tall fescue	6 lb.
Alsike clover	4 lb.
Redtop	4 lb.
Alsike clover	4 lb.

Drouthy soils	
Alfalfa	8 lb.
Orchardgrass	4 lb.
Alfalfa	8 lb.
Tall fescue	6 lb.
Alfalfa	8 lb.
Bromegrass	6 lb.

Hog Pastures

(for anywhere in Illinois)

Alfalfa	6 lb.
Ladino	2 lb.

closely so all species are equally grazed, observing fall grazing restrictions, and fertilizing with lime, phosphorus, and potassium or other nutrients as needed are practices that will lengthen the life of legumes in pastures. In hay fields, harvesting alfalfa in the late-bud to early bloom stage at the first harvest and every 35 to 40 days thereafter until the last safe cutting date in September and applying needed fertilizers will all help maintain legumes in mixtures with grasses.

Suggested legume and grass mixtures for general soil conditions, climatic regions, and pasture and hay use are shown on this page. The seeding rates are listed in pounds per acre.

Varieties

Variety selection of alfalfa depends on how long the stand is to be productive. Use bacterial-wilt-resistant varieties if the hay or pasture field is to be used more than two years. Use either the bacterial-wilt-resistant or susceptible varieties if the field is to be used for hay or pasture two years or less. There are several varieties with

Table 26. — The Yields of Leading Alfalfa Varieties Given as Percentages of Certain Check Varieties Tested Two Years or More in Illinois[a]

Variety	Flemish or non-Flemish	Bacterial wilt	Nor. Ill.	Cen. Ill.	So. Ill.
A-24	F	S[b]	105	100	...
A-59	NF	R[c]	100	102	...
ACCO 235	NF	R	104	...	...
Alfa	F	S	99	103	104
Apex	F	MR[d]	107	106	104
Arnim	F	S	96	103	104
Atlantic	NF	MR	99	102	...
ATRA 55	NF	R	...	101	...
Buffalo	NF	R	98	99	100
Cardinal	F	S	96	98	107
Cayuga	NF	R	104	104	99
Cherokee	NF	S	104	103	107
Cody	NF	R	95	102	101
Dawson	NF	R	...	102	...
DeKalb 123	NF	R	104	101	111
DeKalb 153	NF	S	101	105	97
DuPuits	F	S	102	100	102
Europa	F	S	95	100	104
FD 100	F	S	98	100	100
Flamande SC 118	F	S	100	100	104
Flandria	F	S	102	109	105
Franck's Langmeiler	NF	([e])	97	100	106
Glacier	F	S	97	101	106
Haymor	F	S	99	103	106
Iroquois	NF	R	104	97	...
Kanza	NF	R	...	99	...
Milfeuil	F	S	93	101	108
Mustang	NF	R	101	103	...
Narragansett	NF	S	103	97	...
Orca	F	S	108	...	...
Orchies	F	S	98	106	106
Pat 30	F	MR	102	108	98
Progress	NF	R	98	102	101
Ranger	NF	R	101	100	100
Saranac	F	MR	105	105	108
Scout	NF	R	100	102	98
Socheville	F	S	...	111	103
Stride	F	S	91	100	99
Team	NF	S	105	97	...
Tempo	NF	R	104	106	115
Titan	NF	R	102	100	98
Vernal	NF	R	102	100	100
Warrior	F	MR	100	99	103
Weevlchek	NF	R	105	106	...
WL 202	NF	R	103	103	109
WL 210	NF	R	109	102	114
WL 303	NF	MR	108	107	109
WL 305	NF	MR	106	108	110
WL 306	NF	R	110	...	...
520	NF	R	...	100	...
522	NF	R	102	98	102
525	NF	R	106	104	110

[a] The check varieties were Vernal, Ranger, Atlantic, and Buffalo. The performance of the other varieties was tested against these varieties.
[b] S = susceptible.
[c] R = resistant.
[d] MR = moderate resistance.
[e] Information not available.

moderate resistance to bacterial wilt and they may be expected to be productive for three to five years. It is risky to expect these moderately resistant varieties to remain in adequate stand beyond five years.

Flemish varieties recover rapidly after harvesting, bloom earlier in the spring, and grow later into the fall than most non-Flemish varieties. Some Flemish varieties are marginal in winter hardiness for northern Illinois. The less hardy varieties may be injured by winter without noticeable loss of stand, but the yields are reduced. Yield records over three or four years form a basis for judging winter hardiness of a variety for a particular area of the state (Table 26).

Table 27. — Red Clover Variety Yields, Urbana, 1968-1969

Variety	Anthracnose resistance	Tons dry matter per acre
Chesapeake	Southern	3.56
Kenland	Southern	3.24
Pennscott	Southern	3.18
Dollard	Northern	3.60
Lakeland	Northern	3.78
LaSalle	Northern	3.40
Mammoth	....	3.42
Altaswede	....	2.96

Red Clover

There are fewer varieties of red clover than alfalfa. There was some interest in mammonth red clover, particularly Altaswede. Mammoth red clovers make one large crop and have little or no regrowth, resulting in a lower seasonal yield. Mammoth red clover is a good plow-down crop, but is usually inferior as a hay crop compared with medium red clover (Table 27). Use northern-anthracnose-resistant varieties in the northern one-third of the state and southern-anthracnose-resistant varieties in the southern two-thirds of the state.

Ladino clover thrives best on fertile, moist soils. Add grasses in mixtures with ladino to reduce bloat danger. Plant certified seed since uncertified ladino is often merely white clover. Ladino fits best in seedings intended for pasture or for both hay and pasture. For best results, use Merit ladino clover.

Birdsfoot trefoil is a high-quality forage with excellent nutritive value. It does not decline in digestibility with maturity as rapidly as alfalfa and need not be harvested until in the half-bloom stage. Birdsfoot matures 1 to 2 weeks later than alfalfa. The yield potential of birdsfoot is about 60 percent of alfalfa. Seedlings and spring growth are not vigorous. Competitive grasses such as orchardgrass and smooth bromegrass often crowd out birdsfoot trefoil, thus timothy or Kentucky bluegrass is suggested as associated grass species with birdsfoot trefoil.

Under grazing conditions, rotational grazing is desirable to maintain the trefoil in the stand. A moderate stocking rate in which the pastures are well used and not grazed extremely short is preferred for maximum animal production over several years. Rotational grazing periods of 10 to 15 days with 30- to 35-day rest periods before regrazing are desirable.

Establishment of birdsfoot trefoil is more difficult than alfalfa or red clover. Early spring seedings have been most successful. Late summer seedings frequently fail to develop enough plant size to survive the winter. Band-press or broadcast seeding on a firm seedbed and rolling the seed into the seedbed with a corrugated roller are suggested practices. Band-press seedings have been more successful than broadcast seedings where soil fertility is limiting.

Use the correct inoculant with trefoil seed. Alfalfa inoculum will not work, and few Illinois soils contain trefoil inoculum from previous trefoil plantings. Leave trefoil plantings down for several years since they establish slowly.

The varieties Empire and Dawn are particularly adapted to pasturing because of their low growth habit. Leo and Viking are more upright in growth habit and you can use them in rotationally grazed pastures or as hay crops.

Use birdsfoot trefoil in the northern half of the state. Diseases limit the life of birdsfoot trefoil to one or two years throughout southern Illinois.

Crownvetch is a legume that can spread by underground rootstocks similar to grasses with rhizomes. This legume is widely used to stablize steep slopes, particularly roadside cuts. Crownvetch is slow to establish but develops a heavy growth in two to three years that competes extremely well with weeds and brush. The forage value of crownvetch is being investigated. Many reports have been favorable. There are some major disadvantages to crownvetch. Its yield potential is about 60 percent of alfalfa. The seed germination rate and seedling growth rate are slow, thus making weed control in seedings more difficult. The seed cost is quite high compared with alfalfa.

Harvest crownvetch for forage use after it reaches 10 percent bloom. Make the last harvest of the season no later than September 1 in central and northern Illinois and September 15 in southern Illinois.

Lespedeza is adapted to the southern half of the state. Though generally low yielding, it resists drouth and tolerates low fertility better than alfalfa and clovers. Korean is the suggested annual type. For natural reseeding, cut the hay early and leave the stubble 4 to 6 inches high. Lespedeza improves summer pastures in the southern one-third of the state.

Sericea lespedeza is a perennial type you can use to advantage for soil improvement south of U.S. 50. It grows on soils too poor to support other perennial legumes and once established will outlast other legumes. Sericea is low in palatability, so it is not desirable as a pasture plant.

Smooth bromegrass is a very winter-hardy, sod-forming grass. This grass develops rhizomes that result in sod formation. Smooth bromegrass is sensitive to management practices. Harvests made when first growth is heading and when new tiller growth is high enough that the growing point is clipped off, result in every slow recovery of the grass. Harvest the first growth just as heads emerge. The new tillers are not likely to be developed enough to be clipped off. Clip bromegrass short for highest yields. The following figures give smooth bromegrass yields at three cutting heights at Urbana from 1958 to 1960:

Cutting height	Tons of dry matter per acre per year
1 inch	3.0
2 inches	2.8
4 inches	2.3

Adding nitrogen to smooth bromegrass results in more tiller development and reduced rhizome development. Plants increase in diameter by the production of new rhizomes. Fertilized plants produce a denser crop of tillers, resulting in more tillers per unit area than from unfertilized plants.

Smooth bromegrass is more drouth tolerant than orchardgrass or timothy. It usually is less productive than orchardgrass and more productive than timothy in midsummer. The first cutting of smooth bromegrass is usually the highest yielding harvest of the season. More of the total seasonal yield is obtained in the first harvest if the number of harvests are few, for example three. Increasing the number of harvests to five results in a more equal distribution of forage production but a lower total seasonal yield. The following figures show the smooth bromegrass yields with three, four, and five harvests per season at Urbana from 1958 to 1960:

Number of harvests	Tons of dry matter per acre per year
3	3.5
4	2.5
5	2.2

The emergence of the first seed heads of the smooth bromegrass matches closely the emergence of the first flowers of alfalfa varieties such as Vernal. The best harvest dates for the two species are well matched.

Timothy is an excellent grass in hay mixtures with red clover and birdsfoot trefoil because they mature near the same time. Production after the first cutting is low. It has less drouth resistance than bromegrass and requires better drainage than tall fescue.

Tall fescue is a coarse-textured, vigorous pasture grass well suited to heavy clay loams and poorly drained soils throughout central and southern Illinois. It is not as palatable as timothy, smooth bromegrass, or orchardgrass, but does support beef cattle very well. It has had limited use as a pasture plant throughout the state and is most widely used in the southern third of the state by beef cow herds for late fall, winter, and early spring pasture. Tall fescue grows well during hot, dry periods, but the forage is low in palatability.

A foot rot of cattle known as fescue foot has occurred very infrequently. Good grazing management of the tall fescue and providing other kinds of grass pastures has eliminated fescue foot problems. Most pasture programs using tall fescue should have an equal acreage of other grass or grass-legume pasture.

Ky 31 is the most productive variety. Kenwell is a more palatable variety but is less vigorous.

Reed canarygrass is the most productive perennial hay and pasture grass tested in Illinois. It is not palatable when mature. Clipping or frequent harvesting is necessary to maintain palatability. Reed canarygrass has been used mainly on very wet soils, however it also does well under drouthy conditions.

Orchardgrass is a moderately winter-hardy bunchgrass that matures earlier than timothy or smooth bromegrass. Varieties differing by as much as two weeks in maturity have been selected.

Orchardgrass is not winter hardy enough to be highly reliable in the northern quarter of Illinois. The grass survives many of the winters, but occasionally stands are killed out or are severely injured in this area. In central and southern Illinois, orchardgrass is one of the higher yielding grasses, having the desirable attribute of more summer growth than timothy or smooth bromegrass. Tall fescue also makes mid-summer growth but the palatability is much lower than either the spring or fall growth and much lower than the mid-summer growth of orchardgrass.

Harvest orchardgrass or graze it before the heads are fully exerted. Orchardgrass is well adapted to grazing or clipping management. Clipping to a 1-inch stubble has yielded more than clipping at a 2- or 4-inch stubble.

Irrigated orchardgrass cut at 1-inch stubble height has resulted in significant loss of stand. Growth is stimulated by the irrigation and the stem and leaf-sheath growth is greater than normal. This stimulated growth raises the leaf collar, a prime meristematic region (area that includes formative tissues), higher from the plant crown than normal and makes it more vulnerable to removal by close clipping of close grazing. When the leaf-collar region is removed, recovery growth is slow because new growth must then originate from the crown. If the leaf-collar region remains intact, new leaf material is readily grown after the upper leaf material is harvested.

Clipping to a stubble height of 1 inch generally will produce higher yields except under irrigated conditions or following high rates of nitrogen fertilization (100 pounds of nitrogen or more). The stimulated growth from high nitrogen has the same effect on the height of the leaf-collar region as does irrigation. Where high nitrogen rates are used or irrigation is practiced, clip orchardgrass or graze it no shorter than 2 or 3 inches.

Fall grazing or clipping should also be at 2 or 3 inches to increase the accumulation of carbohydrates in basal parts of the plants to aid winter survival and vigorous spring growth.

Varieties of orchardgrass with improved yield and disease resistance are available, so commercial classes of orchardgrass seed need not be depended on in the future. Named varieties are preferred to unnamed seed lots. Several varieties are higher yielding than many others. Unnamed seed lots could be seed of high-yielding or low-yielding strains. Some of the named varieties are described here. Yields are shown in Table 28.

Potomac is an early maturing, high-yielding strain developed at Beltsville, Maryland. It is dark green, leafy, and stands erect. It has rust resistance and has persisted in stands for several years where adapted. Its winter hardiness is average.

Napier, a private selection, matures 2 to 4 days later than Potomac. It is winter hardy and has rust and leaf-blight resistance. It is a vigorous, high-yielding variety with good recovery growth.

Boone is a selection from the Kentucky Agricultural Experiment Station. It is 3 to 5 days later maturing than Potomac. It has had a good yield record in Kentucky and central Illinois. Boone has good persistence, maintaining a high yield as the stand ages. Boone has some resistance to rust but is not as resistant as Potomac.

Sterling is a selection from the Iowa Agricultural Experiment Station. It is considered mid-early in maturity. It is winter hardy, yields well, and is moderately susceptible to rust and leaf streak.

Pennmead is a selection from the Pennsylvania Agricultural Experiment Station and U.S. Regional Pasture Laboratory. It is about five days later maturing than Potomac. It is high yielding, leafy, and compatible with early maturing alfalfa varieties. Pennmead makes slightly more recovery growth in mid-summer than most varieties and grows late into the fall.

Pennlate is a selection from the Pennsylvania Agricultural Experiment Station and U.S. Regional Pasture Laboratory. It matures 7 to 10 days later than Potomac. Its winter hardiness is average compared with most varieties and hardier than S-37. Its yield is greater than S-37.

S-37 is a selection from the Welsh Plant Breeding

Table 28. — Orchardgrass Variety Yields, Urbana, 1967-69

Variety	Tons dry matter per acre	
	DeKalb	Urbana
Akaroa	3.36	2.65
Boone	....	3.53
Common	3.30	3.28
Danish	3.38	2.91
Latar	3.31	2.64
Masshardy	3.44	2.41
Napier	3.50	3.32
Pennlate	3.58	2.81
Potomac	....	3.35
Sterling	....	3.31

Station, Aberystwyth, Great Britain. It matures about 10 days later than Potomac, often a day or two later than Pennlate. It is fairly leafy, more so than Danish. The yield and winter survival have been less than Pennlate and other late-maturing varieties.

Rideau is a selection from the Central Experimental Farm, Ontario, Canada. It is a late-maturing variety with less early season production and more mid-season production than early maturing varieties. Its maturity matches Vernal alfalfa.

Latar is a selection from the Plant Materials Center, SCS, Pullman, Washington. It is late maturing, 10 to 14 days later than Potomac. Latar is leafy and light green in color. The leaves are broad and well distributed. The variety is vigorous, low in lignin, and high in digestibility.

Danish is imported from Denmark. This type usually is very erect and lacks leafiness. Winter hardiness is often less than the varieties above.

Supplemental Annual Forage Crops

Sudangrass is an ideal crop for increasing summer pasture. Piper is the highest yielding, disease-resistant sudangrass variety. It is highly productive during the late summer months. Do not pasture sudangrass until it is 18 inches tall. Shorter growth may offer some danger of prussic acid poisoning, although the danger is slight in Illinois. A height of 18 to 24 inches for grazing or harvesting produces the most digestible protein and energy.

Sudangrass hybrids and sorghum-sudangrass hybrids are grown in much the same way as sudangrass. Numerous commercial varieties are on the market. In Illinois tests, these have generally outyielded Piper sudangrass when cut once or twice during the season. But Piper yields more when four harvests are made. The sudan hybrids and sorghum-sudan hybrids are somewhat higher than Piper in prussic acid potential, but they should be safe if you do not graze or harvest until first growth or regrowth is 24 inches tall.

The potential for prussic acid poisoning is increased when the plant growth rate is reduced by factors like drouth or cool temperatures or when cattle are particularly hungry for green feed. New growth is high in prussic acid potential. High nitrogen fertilization also adds to the potential for prussic acid build-up. New growth after frost is also high in prussic acid potential. Dry ensiled plant material high in prussic acid potential before using it as a feed. Green-chopping and then feeding promptly is usually a safe use of plant material high in prussic acid potential. Allowing the green-chopped forage to stand and ferment during the day or overnight before feeding has resulted in toxic reactions.

You can use sudangrass, sudangrass hybrids, and sorghum-sudan hybrids for pasture, green-chop, or silage for extra feed during July, August, and September. With good yields these crops can carry 3 to 5 animals per acre through the summer.

Do not graze horses on sudangrass and related hybrids because cystitis syndrome may occur with this crop.

For best results, drill seed in late May or early June, using 25 to 35 pounds of seed per acre. Fertilize as for corn.

Millets of the Japanese, German, and Pearl varieties grow in Illinois, but they yield less than sudangrass and hybrids of sudangrass and sorghums.

Sorghum almum or sorghum grass produces an inferior quality of forage and is more likely to cause prussic acid poisoning than other crops. Sorghum almum is a hybrid between sorghum and Johnsongrass. The sorghum almum seed is difficult to distinguish from that of Johnsongrass, and is a noxious weed as is Johnsongrass.

Pasture Management

Continuous grazing reduces total yields and shortens the life of tall growing grasses and legumes. Divide pastures into at least two or three fields. Use one while the others are recovering and making new growth.

After you move animals from one pasture to another, clip the remaining forage from the pasture just grazed to improve the quality and yields of future growth. This practice also eliminates weeds before they go to seed.

Plan for several different pasture crops so you can have fresh, green pastures from early spring to late fall.

Winter Pastures

Winter pastures are important in reducing wintering costs of beef cow herd operations. Very successful winter grazing programs with tall fescue have been developed for southern Illinois. The spring and summer growths (two harvests) are cut and baled into round bales and left in the field. Large windrows are used at the first harvest to concentrate the bales to minimize interference at the second harvest. The third growth is allowed to accumulate. The winter grazing season begins in late fall, varying with supply of other pasturages, and ends in late March or early April. Nitrogen (75 pounds per acre) and other nutrients are applied as needed soon after removal of the animals in the spring. An additional 75 pounds of nitrogen is applied after the first harvest, which may be a seed crop if desired.

Mid-Summer Pasture

Mid-summer pastures have often limited the size of beef cow herds where bluegrass was the principal pasture grass and no stored feeds were planned for this period. Highly digestible, nutritious pasture is needed in summer months to maintain milk flow and this helps produce

Table 29. — Suggested Rates for Phosphorus Applied Before Seeding, Based on Expected Yield in Seeding Year for Alfalfa and Alfalfa-Grass Mixtures

P_1 test			Broadcast seeding		Band seeding	
Soil region (see map, page 37)			Expected yield per acre		Expected yield per acre	
			2-3 tons	3-5 tons	2-3 tons	3-5 tons
low	*med.*	*high*	*Pounds of P_2O_5 per acre*			
25	15	10	120	180	60	90
30	20	15	90	150	50	80
38	30	20	60	90	30	60
45	40	30	60	60	30	40
60	50	40	..	..	30	30

calves with heavy weaning weights. Alfalfa-orchardgrass in southern Illinois or alfalfa-smooth bromegrass in northern Illinois, when rotationally grazed, provides this high-quality pasture. Save about half of the acreage in this mixture for hay harvesting. The bales are left in the field and provide the extra feed needed in mid-summer when plant growth slows.

Fertilization of Hay and Pasture

At or Before Seeding

Lime. Apply lime at the rates suggested in Figure 10, page 35. If rate requirements are in excess of 5 tons, apply half before the primary tillage (in most cases, plowing) and half before the secondary tillage (harrowing, disking). Apply rates of less than 5 tons at one time, preferably after plowing, but either before or after is acceptable.

Nitrogen. Up to 20 pounds per acre may help assure rapid seedling growth on soils with less than 2½ percent organic matter. If you band-seed, apply nitrogen with the grain drill with phosphorus. For broadcast seeding, apply broadcast with phosphorus and potassium.

Phosphorus. Apply all phosphorus at seeding time (Table 29) or broadcast part of it with potassium. For band seeding, reserve a minimum of 30 pounds of P_2O_5 per acre for this purpose. For broadcast seeding, broadcast all the phosphorus with potassium after primary tillage and before secondary tillage.

Potassium. Broadcast potassium before or after primary tillage (Table 30). For band seeding you can apply a maximum of 30 to 40 pounds K_2O per acre in the band. For broadcast seeding, apply all the potassium after the primary tillage. You can apply a maximum of 300 pounds of K_2O per acre in the seedbed.

Maintenance Fertilization

Make maintenance application (Table 31) annually after the first or second year. Maintenance applications are based on yields, percent of nutrient removal, soil-nutrient-

Table 30. — Suggested Rates for Potassium Applied Before Seeding, Based on Indicated Expected Yield in Seeding Year of Alfalfa and Alfalfa-Grass Mixtures

K test level	Soils low in potassium-supplying power				Soils medium to high in potassium-supplying power			
	Expected yield: tons per acre				Expected yield: tons per acre			
	2-3	3-5	2-3	3-5	2-3	3-5	2-3	3-5
	For 1 year		For 2 years		For 1 year		For 2 years	
	Pounds of K_2O to apply per acre							
90 or less	150	225	300	450[a]	These soils seldom if ever test below 121			
91–120	135	200	270	400[a]				
121–150	120	180	240	360[a]	110	160	220	320[a]
151–180	105	160	210	320[a]	90	135	180	270
181–210	90	135	180	270	75	115	150	230
211–240	75	115	150	230	60	90	120	180
241–300	60	90	120	180	..	70	..	135
Above 300	Test every 4 years and adjust annual rates to maintain the test level							

[a] May cause seedling injury. To avoid risk, incorporate before plowing or by deep disking, or apply the rate suggested for 1 year.

supplying power, and whether K was applied for 1 or 2 years (see Table 30). Approximate nutrient removals by alfalfa per ton of dry matter are: phosphorus, 11 pounds of P_2O_5, and potassium, 50 pounds of K_2O.

Nitrogen. The most profitable nitrogen program for legume-grass mixtures is determined by the percent of legume in the stand. When the alfalfa or lespedeza stand is *30 percent or more* of the mixture, the main objective in fertilizing is to *maintain the legume.* If heavy applications of nitrogen are made when the legume stand is still excellent, the grass is given a competitive advantage and tends to crowd out the legume.

After the legume has declined to *less than 30 percent* of the mixture, the objective in fertilizing is to *increase the yield of grass.*

The suggested rate of nitrogen is about 50 pounds per acre when the legume makes up 20 to 30 percent of the mixture, and 100 pounds when the legume is 0 to 20 percent. Of this 100 pounds, it is best to apply one-half

Table 31. — Suggested Annual Maintenance Fertilization for Alfalfa and Alfalfa-Grass Mixtures After Soil Tests Are Built to High Levels

Nutrient-supplying power rating of soil[a]	Approximate percent of nutrients removed to be supplied by annual fertilization	
	Phosphorus	Potassium
Low	100	100
Low to medium	80	90
Medium	70	80
Medium to high	60	70
High to medium	50	60
High	50	50

[a] See pages 37 and 39.

in late winter to early spring and one-half after the first cutting.

Farmers who maintain pure grass probably will find it profitable to apply 80 to 100 pounds early in the spring, 50 pounds after the first cutting, and 50 pounds about September 1 to 15 if they need extra fall feed.

Rock Phosphate. Each 1,000 pounds of rock phosphate per acre supplies 13 pounds of immediately available P (30 pounds of P_2O_5), plus some available P each year as the rock reacts with soil acids. This is adequate for establishment on soils that test medium by the P_1 test and medium to low by the P_2 test. For soils that test very low by both tests, use either 1,500 pounds of rock or the amount of available P in Table 19. A liberal treatment *before planting* is adequate for three to four years.

Boron. Boron deficiency symptoms appear on second- and third-cutting alfalfa in drouth periods in many areas of Illinois. But in 15 trials boron fertilizer increased the forage yield in only one field on the second cutting.

Table 32. — Suggested Application of Rock Phosphate, Based on the P_2 Soil Test

P_2 test	Rating[a]	Rock phosphate for 8 to 10 years
		lb. per acre
Below 21	Very low	1,500
21–32	Low	1,300
33–53	Slight	1,000
54–75	Medium	800
76–92	High	No build-up application,
93 and above	Very high	but soluble phosphate is suggested for wheat

[a] If the P_2 test is above 50 and has been built to this level through applications of soluble phosphates rather than rock phosphate, the rating of the P_2 test in the table is too low and the suggested rate of rock phosphate is too high. A P_1 test is needed to show the status of available phosphorus.

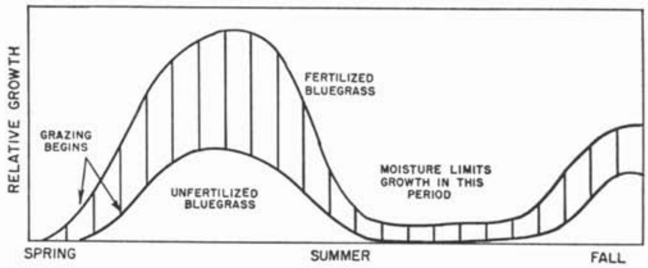
There is no recommendation for general application of boron in Illinois. If you suspect there is a boron deficiency, topdress strips in your alfalfa fields with 30 pounds per acre of household borax per acre (3.3 pounds of actual boron).

Fertilizing Permanent Pasture

Two adjustments are made from the usual sampling and liming procedures: soil samples are taken from the surface 3 inches, and the rate of liming is reduced about one-third to one-half because (a) the lime is mixed with less soil and therefore it has less soil with which to react and (b) the species in permanent pastures have a lower lime requirement than alfalfa.

Nitrogen applied in the late fall or very early spring can advance grazing at least a week and greatly increase early carrying capacity (Fig. 9).

Each application of nitrogen (50 to 60 pounds) will last about 6 weeks. Repeated applications will be effective as long as moisture is adequate (usually from May 15 to June 1 in southern Illinois and June 1 to 15 in northern Illinois). Nitrogen will become effective again after fall rains begin.



Relative growth of nitrogen-fertilized and unfertilized bluegrass pasture during the grazing season. (Fig. 9)

SOIL TESTING AND FERTILITY

Soil Testing

Soil testing is the most important single guide to the profitable application of fertilizer and lime. When soil test results are combined with information about the nutrients that are available to the various crops from the subsoil, the farmer has a reliable basis for planning his fertility program on each field.

Sampling every 4 years is strongly suggested. Sampling instructions are available from soil testing laboratories.

The most common mistake is to take too few samples to represent the field adequately. Following shortcuts in sampling may produce unreliable results and lead to higher fertilizer costs or lower returns or both.

What tests to have made. Illinois soil testing laboratories are equipped to test soils for pH (soil acidity), P_1 (available phosphorus), P_2 (reserve phosphorus), and K (potassium). No test for nitrogen has proved successful enough to justify a recommendation by University of Illinois agronomists that laboratories provide the test.

Soil tests for certain secondary and micronutrients may warrant consideration under particular circumstances. Tests may be made for most of them but the tests are costly and the interpretation is less reliable than the tests for lime, phosphorus, and potassium. Complete field history and soil information are therefore important in interpreting the tests for treatments. Crops differ in their nutrient requirements and this affects the choice and usefulness of special tests. The boron test, for example, is useful for alfalfa and the manganese test is useful for soybeans.

Secondary and micronutrient tests may be useful for:

1. Trouble shooting — diagnosing symptoms of abnormal growth. Paired samples representing areas of good and poor growth are needed for analyses.

2. "Hidden-hunger checkup" — identifying deficiencies before symptoms appear. Soil tests have little value in indicating marginal levels of secondary and micronutrients when crop growth is apparently normal. For this purpose plant analysis may yield more useful information.

For a more complete discussion of secondary nutrients, micronutrients, and plant analysis, refer to page 41.

Interpreting soil tests. The Department of Agronomy has reexamined all available data and revised the interpretations of some soil tests.

The main change is in greater emphasis on the influence of soil type on suggested lime and fertilizer application rates.

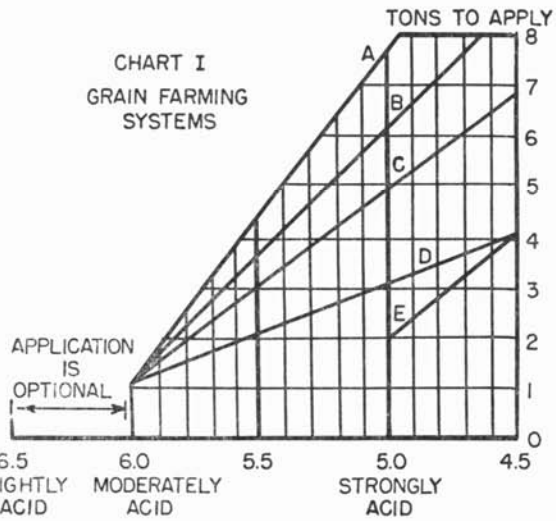
Lime

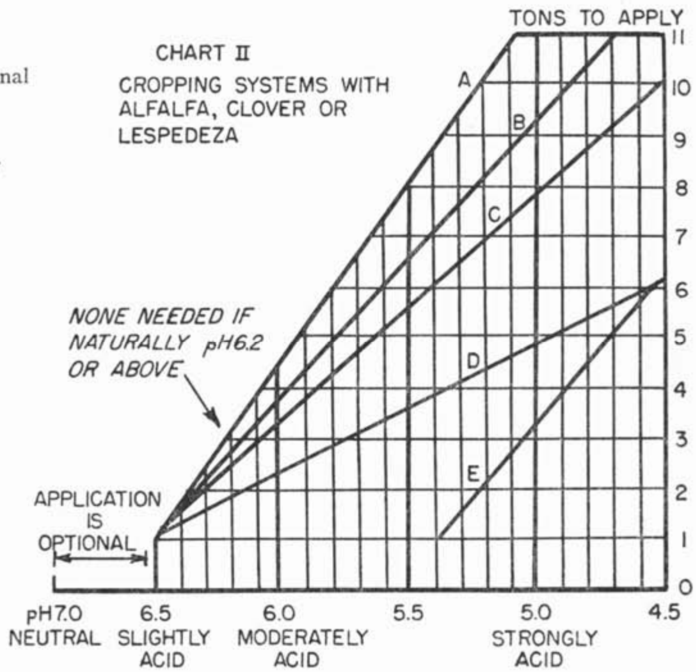
About 1,000,000 tons of limestone are needed each year in Illinois to offset the acidity caused by nitrogen ferti-

Suggested limestone rates based on soil type, pH, and cropping system. (Fig. 10)

STEPS TO FOLLOW

1. Use Chart I for grain systems, Chart II for alfalfa, clover, or lespedeza.
2. Decide which soil class fits your soil:
   A. Silty clays and silty clay loams (dark).
   B. Silty clays and silty clay loams (light and medium). Silt and clay loams (dark).
   C. Silt and clay loams (light and medium). Sandy loams (dark). Loams (dark and medium).
   D. Loams (light). Sandy loams (light and medium). All sands.
   E. Muck and peat.
3. Find your soil's pH along the bottom of the chart.
4. Follow up the vertical line until it intersects the diagonal line A, B, C, D, or E that fits your soil.
5. Read the suggested rate of limestone along the right side.





lizers. Farmers who regularly apply 150 to 200 pounds or more of nitrogen in an intensive corn cropping system are advised to test their soil every four years and apply limestone if needed. Even lower nitrogen rates will cause sandy soils to become acid rapidly.

The tonnage of limestone in Illinois had been holding steady since 1963, but dropped sharply in 1968, caused partly by an unfavorable fall for spreading.

Suggested pH goals. For cropping systems with alfalfa and clover, maintain a pH of 6.5 or above. But if the soils are pH 6.2 or above without ever having been limed, neutral soil is just below plow depth and it will probably not be necessary to apply limestone.

For cash-grain systems (no alfalfa or clover), maintaining a pH of at least 6.0 is a realistic goal. If the soil test shows that the pH is 6.0, apply limestone to prevent a drop in pH below 6.0. Farmers may choose to raise the pH to still higher levels. After the initial investment, it costs little more to maintain a pH of 6.5 than 6.0. The profit over a 10-year period will be affected very little, since the increased yield will about offset the original cost of the extra limestone (2 or 3 tons per acre) plus interest.

Research indicates that a profitable yield response from raising the pH above 6.5 in cash-grain systems is unlikely, and the risk of nitrogen loss through denitrification is increased unnecessarily.

Liming treatments based on soil tests. The limestone requirements in Fig. 10 are based on these assumptions:

1. A 9-inch plowing depth. If plowing is less than 9 inches deep, reduce the amount of limestone; if more than 9 inches, increase the lime rate proportionately.

2. Typical fineness of limestone: 90 percent through 8-mesh; 60 percent through 30-mesh; 30 percent through 60-mesh. If the limestone is not as fine as indicated above and if a quick effect is desired, apply more limestone than indicated in the charts.

3. A calcium carbonate equivalent (total neutralizing power) of 90 percent. The range in neutralizing power of standard agricultural limestone in Illinois is about 80 to 105. The rate of application may be adjusted according to the deviation from 90.

Information on the neutralizing power and fineness of limestone is sent every six months to county advisers.

If high initial cost is not a deterrent, you may apply the entire amount at one time. If cost is a factor and the amount of limestone is 6 tons or more, apply it in split applications of about two-thirds the first time and the remainder three or four years later.

Calcium-Magnesium Balance in Illinois Soils

Soils in northern Illinois contain more magnesium than those in central and southern sections because of the high magnesium content in the rock from which the soils developed. This has caused some to wonder whether the magnesium was too high. There have been reports of suggestions from some laboratories located outside Illinois that either gypsum or low-magnesium limestone from southern Illinois quarries should be applied. At the other extreme some laboratories have told southern Illinois farmers to buy high-magnesium limestone from northern quarries.

The following is a quotation from a report on research conducted at the University of Illinois:

"Varying the calcium to magnesium (Ca:Mg) ratio had no significant effect on the yield of either corn or soybeans, provided the amount of calcium was equal to, or greater than, the amount of magnesium in the culture, and provided sufficient quantities of the two ions were present. When . . . magnesium exceeded calcium . . . yields were greatly decreased. From these data indications are that Ca:Mg ratios do not play an important role . . . as long as calcium exceeds the exchangeable magnesium. . . .

"In these experiments, when the Ca:Mg ratio was less than 1:1, there may have been an actual shortage of calcium. That would not be the case under field conditions in any soil limed to the suggested pH goal."

A study of northern Illinois soils showed that in no case did calcium to magnesium approach the 1:1 ratio reported to be critical in the research studies.

Adding high-magnesium limestone can never raise magnesium above calcium, because pure dolomite contains 55 percent calcium carbonate to 45 percent magnesium carbonate and thus adds more calcium than magnesium.

No one operating a soil-testing laboratory or selling fertilizer in Illinois has put forth any research to justify concern over the calcium:magnesium ratio.

Based upon a study of the available information on (a) the calcium:magnesium ratio in Illinois soils, and (b) the tolerance of field crops to a wide range in Ca:Mg ratios, *there is no agronomic reason to recommend* either that farmers in northern Illinois bypass local sources which are medium to high in magnesium and pay a premium for low-magnesium limestones from southern Illinois, or that farmers in southern Illinois order limestone from northern Illinois quarries because of magnesium content.

Phosphorus

Illinois has been divided into four regions in terms of inherent phosphorus-supplying power of the soil below plow layer in dominant soil types (Fig. 11).

High phosphorus-supplying power means:

1. The amount of available phosphorus (P_1 test) is relatively high.

Phosphorus-supplying power. (Fig. 11)

2. The conditions are favorable for good root penetration and branching in the subsoil.

Low phosphorus-supplying power may be caused by one or more of these factors:

1. A low supply of available phosphorus in the subsoil because (a) the parent material was low in P; (b) phosphorus was lost in the soil-forming process; or (c) the phosphorus is made unavailable by high pH (calcareous) material.
2. Poor internal drainage that restricts root growth.
3. A dense, compact layer that inhibits root penetration or spreading.
4. Shallowness to bedrock, sand, or gravel.
5. Drouthiness, strong acidity, or other conditions that restrict crop growth and reduce rooting depth.

Regional differences in P-supplying power are shown in Fig. 11. Parent material and degree of weathering were the primary factors considered in determining the various regions.

The "High" region occurs in western and central Illinois. The primary parent material was more than 4 to 5 feet of loess. The soils are leached of carbonates to depths of more than 3½ feet. Roots can easily spread in the moderately permeable profiles. The loess was high in phosphorus.

The "Medium" region is in east central Illinois. The soils were formed from 3 to 5 feet of loess over loam to silty clay loam glacial till. Carbonates are nearer to the surface than 3½ feet in many soils of the region. The till has higher bulk density, may have higher clay content, and is less permeable to air and water than the overlying loess. Root development is more likely to be restricted than in the "High" region.

The "Low to Medium" region is in south central and southern Illinois. The soils were formed from 2½ to 7 feet of loess over weathered Illinoian till. The profiles are more highly weathered than in the other regions and are slowly or very slowly permeable. Root development is more restricted than in the "High" and "Medium" regions. Subsoil phosphorus levels may be rather high by soil test in some soils of the region, but this is partially offset by conditions that restrict rooting.

The "Low" region is in northeastern Illinois. The soils were formed from thin (less than 3 feet) loess over glacial till. The glacial till ranges in texture from gravelly loam to clay in various soil associations of the region. The tills are generally low in available phosphorus. In addition, shallow carbonates further reduce the P-supplying power of the soils of the region. High bulk density and slow permeability in the subsoil and substratum restrict rooting on many soils of the region.

The four regions are separated to show broad differences between them. Parent material, degree of weathering, native vegetation, and natural drainage vary within a region and cause variation in P-supplying power. It appears, for example, that soils developed under forest cover have more available subsoil phosphorus than those developed under grass. Whether this is offset by a lower amount of phosphorus in organic matter in the surface has not been determined.

The importance of subsoil phosphorus may be different for corn, soybeans, small grains, and deep-rooted perennial legumes. The significance of subsoil phosphorus is likely to depend on the depth of rooting at the time during the growing season when phosphorus is most needed. This point is discussed in connection with fertilizer suggestions for each crop.

Additional research is needed to refine the differences within and among regions in P-supplying power of Illinois soils.

Tentative goal for the P_1 test. Major revisions have been made recently in the design of experiments on Illinois research fields in order to more precisely identify the most profitable soil test levels. The following goals are suggested for 1970 but they may be adjusted when additional data are obtained.

Phosphorus-supplying power	*Where row fertilizer is applied for corn*	*Where no row fertilizer is applied for corn*
Low	40	50
Medium	35	40
High	30	35

Specific suggestions for the application of phosphorus to each crop are given in other sections on pages 8 and 21.

Illinois farmers still use large amounts of rock phosphate.

Rock phosphate contains about 3 percent citrate soluble P_2O_5 and this portion (about 1/10 of the total) is as available as that in other phosphorus-supplying fertilizers.

The remainder of the phosphorus is in the apatite form and depends upon the action of soil acids to make it available. Hence, the most economic use of rock phosphate is related to soil pH.

pH 6.5 or above. Rock phosphate is not likely to be as economical a source of phosphorus as phosphates derived from treating rock with acid or heat.

pH 6.0 to 6.5. This is a transition range. Rock phosphate and more readily available forms may be equally profitable up to pH 6.5 if: (1) alfalfa, clover, lespedeza, or birdsfoot trefoil are an important part of the cropping system; (2) the soil is inherently moderately acid; and (3) ACP cost-sharing assistance is available. Otherwise forms other than rock are likely to have an advantage.

pH 6.0 or below. There is enough soil acidity to provide for reaction with phosphate rock and thus rock is likely to be a satisfactory source of phosphorus when large amounts are broadcast in a soil-buildup program.

Applications of rock phosphate (Table 32) are based upon a test that involves a stronger acid extractant (P_2 test) than that used to measure available phosphorus (P_1 test).

How to Handle Very High Soil Tests

A 1968 study in one Illinois county showed that farmers who already had the highest P_1 soil tests were still applying the most phosphorus in fertilizer. In other words, they were ignoring the results of their soil tests.

What advice should dealers, extension advisers, soil testers, and others give to farmers whose soil test reports are *very high* in P and K? In order to earn and keep the respect and confidence of top farmers, sooner or later all who advise farmers must face up to that question. It won't go away. It will arise even more frequently in the future.

Improved practices that continuously raise yield goals call for higher nitrogen levels. A practice that raises the potential yield by 10 percent may, in fact, justify 20 percent more nitrogen.

Not so with phosphorus and potassium. As yield levels rise, more P and K will be needed to *replace the nutrients removed* in the harvested crop. But that is a relatively small amount, 9 pounds extra P_2O_5 and 6 pounds K_2O for example, for 175 bushels of corn compared with 150 bushels.

Both theory and field research show that a soil test level for P or K that produces 99 percent of maximum yield at the 100-bushel level will also produce about 99 percent yield at the 175-bushel yield level. This is because the feeder roots of crops actually contact only 5 to 10 percent of the available phosphorus and potassium in the soil volume occupied by the roots. The higher the crop yield, the larger the root system and thus the more of the available P and K that are reached. It seems likely that there will be *little upward adjustment in the suggested goals* for soil test levels over the next five to ten years.

This is how the situation is handled in the revised soil test report forms from the University of Illinois that are being distributed this year. The person reporting the test chooses one of the following that best describes the soil test level:

1. Phosphorus is below the most profitable level. Phosphorus applications should, therefore, be large enough not only to meet the needs of the next crop but to raise the soil test level.

2. Phosphorus is at the suggested goal. You may broadcast phosphorus this year and thereafter at the rate of 50 pounds of P_2O_5 per year (100 for 2 years, 150 for 3 years) to at least maintain the test level until the field is sampled again.

3. Phosphorus is well above the level believed to be needed. Hence no yield increase is likely from an application of phosphorus this year.

4. Phosphorus is so high that you run the risk of creating problems with other nutrients.

A similar set of choices is given on the potassium report.

Polyphosphates

Polyphosphates are becoming important sources of phosphorus in fertilizers. Here is a brief explanation of how polyphosphates differ from ordinary phosphates.

Except for a small amount of metaphosphate, phosphorus has been supplied until recently in the orthophosphate form. It is the form believed to be used by plants. Polyphosphates are formed when a water molecule H_2O is split off and two or more of the remaining units hook up together into a larger molecule. In simple terms then polyphosphates are mixtures of these "waterless" phosphate units linked together in groups of two up to ten. Actually the superphosphoric acid used to manufacture fertilizers is about one-half orthophosphate and one-half a mixture of polyphosphates.

In order for the phosphorus in polyphosphate to become usable by crops, it must add water and convert to orthophosphate. This likely presents few problems because one-half of the phosphorus is already the ortho form and thus usable, and polyphosphates soon convert to orthophosphate in soils. The conversion is rapid in acid soils and slower where the pH is neutral or above.

Polyphosphates have three properties not already mentioned that differ from orthophosphates:

1. They form complexes in liquid fertilizers that pre-

vent the precipitation of impurities found in wet-process (green) phosphoric acid.

2. They permit higher analysis in fertilizers.

3. They may somewhat increase the availability of certain micronutrients.

Based on the fact that half the phosphorus is already in ortho form and the remainder will likely convert within a few weeks at most, and because of the general scarcity of micronutrient problems, Illinois agronomists feel that fertilizers with polyphosphates are as good as, but not superior to, the usual phosphorus sources.

High Water Solubility of Phosphorus

The purposes of this statement are to list the factors that influence the relationship between yield and degree of water solubility, and to arrive at guides for working under practical field conditions.

pH. As pH increases to the neutral point or above, water solubility becomes increasingly important. The vast majority of soils in Illinois are in the range of pH 5.6 to 7.0 where water solubility is least critical. There are, of course, local exceptions in whole regions or in small areas within fields.

Placement. The degree of water solubility is relatively more important in banded fertilizer than in fertilizer that is broadcast. Of the total amount of phosphorus applied in Illinois, most is broadcast and mixed thoroughly with the soil.

Granule size. To improve effectiveness within the year of application, fertilizers containing phosphorus with relatively *low water solubility* should be supplied *as small granules.*

To reduce the "fixation" and consequent loss in short-term availability of sources that are *high in water solubility,* large granules are preferred on soils that have a high "fixing capacity" (strongly acid soils, for example).

Soil-test P and rate of application. As the total supply of phosphorus (soil-available phosphorus plus newly applied phosphorus fertilizer) increases, the importance of water solubility decreases. In other words, water solubility is of little importance in fields that have already been raised to the desired soil-test goal.

Time interval between application and plant utilization. The rate of chemical change in the phosphorus compounds contained in the fertilizer to other reaction compounds (depending on the fertilizer, soil pH, and other soil factors) was until recent years grossly underestimated. Probably at least three-fourths of the phosphorus is changed chemically by the time the seed germinates and the seedling roots penetrate the fertilizer band. The new compounds *are not water soluble.* They continue, of course, to be important sources of phosphorus, though less readily available than before undergoing change.

In a typical situation only 10 to 20 percent of the phosphorus in fertilizer that is applied for a crop is taken up in the first year. The major supply for the crop comes from the large soil reserve. In other words, the water-solubility principle of the fertilizer applies to only a small, though important, segment of the total available supply.

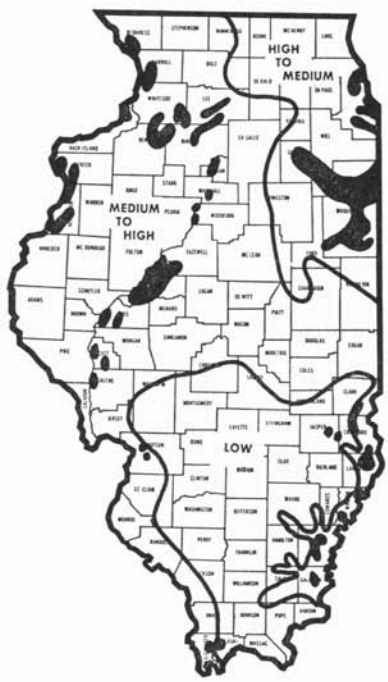
Summary. The degree of water solubility of the portion that is listed as available P_2O_5 on the label is of little importance for typical field crop and soil conditions of medium to high levels of available phosphorus in the soil, typical rates of application on good farms, and broadcast placement. There are exceptions.

For band placement of a small amount of fertilizer that is designed to produce early growth stimulation, at least 40 percent of the phosphorus should be water soluble for application to acid soils and preferably 80 percent for calcareous soils. The phosphorus in nearly all fertilizers sold in Illinois is at least 50 percent water soluble.

For broadcast application on soils that are below pH 7.0, water solubility is not important; for calcareous soils, a high degree of water solubility is desirable, especially on soils that are shown by soil test to be low in available phosphorus.

Potassium

Illinois is divided into four general regions based on potassium-supplying power (Fig. 12). There are, of



Potassium-supplying power. The black areas are sands with low potassium-supplying power. (Fig. 12)

course, important differences among soils within these general regions because of differences in the seven factors listed below.

Inherent potassium-supplying power depends mainly on:

1. The amount of clay and organic matter. This influences the exchange capacity of the soil.

2. The degree of weathering of the soil material. This affects the amount of potassium that has been leached out.

3. The kind of clay mineral.

4. Drainage and aeration. These influence K uptake.

5. pH (very high calcium and magnesium reduce K uptake).

6. The parent material from which the soil formed.

7. Compactness or other conditions that influence root growth.

Sandy soils are low in potassium-supplying power because they are low in exchange capacity and cannot hold much reserve K. In addition, minerals from which sandy soils develop are low in K.

The silt loams in the "Low" area in southern Illinois (claypans) are relatively older soils in terms of soil development and consequently much more of the potassium has been leached out of the root zone. Furthermore, wetness and a platy structure in the upper subsoil may interfere with rooting and with K uptake early in the growing period even though roots are present.

Soils in northeastern Illinois that were formed from medium- to fine-textured till are quite high in potassium by soil test, but restricted drainage may reduce potassium uptake during the early part of the growing season. As a result, those soils with wetness problems have only a medium rating in the ability to supply potassium to crops.

A soil-test goal of 241 to 300 is suggested for all the regions. Rates of potassium suggested in the buildup period and for maintenance on soils that are classified low or medium in supplying power are larger than on those soils that are classified high (Table 33).

Tests on soil samples that are taken *before May 1* or *after September 30* should be adjusted downward as follows: subtract 30 for dark-colored soils in central Illinois; subtract 45 for light-colored soils in central and northern Illinois; subtract 60 for medium- and light-colored soils in southern Illinois; subtract 45 for fine-textured bottomland soils.

On soils that have a very low potassium test, you may apply the suggested initial applications (even up to 300 pounds of K_2O per acre) at one time or you may apply two-thirds the first year and one-third the second year. Approximate maintenance amounts are suggested (60 pounds of K_2O per year or 120 pounds to last two years) for the third and fourth year or until the field is resampled. Specific suggestions for potassium applications for individual crops are given in other sections.

Phosphorus, Potassium, and Lime Applications in No-Plow Systems

A small but growing number of farmers are substituting chisels or zero-tillage systems for the conventional moldboard plow. Since phosphorus and potassium move very little except on extremely sandy soils, zero tillage leaves P and K on the surface, chisels mix a small portion to or slightly below plow depth, but leave most in the surface 2 or 3 inches, and disks or field cultivators mix 3 to 6 inches deep. None of these mix P and K uniformly to normal plow depth.

What is the significance of shallow placement? Nitrogen presents no problem because as soon as the ammonium forms nitrify they move down into the soil readily after rainfall. To answer the question for phosphorus and potassium you must consider two factors:

A. What is the present soil test level?

B. Are plant residues left on the surface?

Table 33. — Potassium Application Rates Based on Tests on Samples Taken Between May 1 and September 30[a]

Soil test range, lb.	Estimated percent of maximum possible yield		Potassium rates for first application to last 2 years			
			Soils **low** in potassium–supplying power		Soils **medium** to **high** in potassium–supplying power	
	Corn, soybeans, alfalfa, clover	Wheat, oats	K_2O, lb.	K, lb.	K_2O, lb.	K, lb.
90 or less	75 or less	90 or less	300	250	These soils are seldom this low.	
91–120	76 to 81	91 to 94	270	225		
121–150	82 to 90	95 to 98	240	200		
151–180	91 to 93	98 or more	210	175	180	150
181–210	94 to 95	98 or more	180	150	150	125
211–240	96 to 97	98 or more	150	125	120	100
241–300	98 or more	98 or more	120	100	Test every 4 years and apply enough to maintain the test.	
Above 300	98 or more	98 or more				

[a] An adjustment is suggested for samples taken earlier or later (see text).

If the soil test level is high throughout the plow layer you are not likely to see any marked effect of leaving fertilizers P and K near the surface. In a moderate drouth, plant roots can get nutrients from the fertile lower part of the old plow layer and from the subsoil.

If the soil tests for P and K are low you will not likely see any ill effect of shallow placement in wet seasons because roots will spread and feed effectively near or at the surface.

But in dry periods P and K near the surface simply are not positionally available to feeding roots when the soil dries out. If the major supplies of nutrients, especially phosphorus, are in the surface few inches the crop will suffer more than if they are mixed to a depth of 8 to 10 inches.

The influence of amount of residues on the surface is indirect through the effect on moisture. Heavy residue serves as a mulch and keeps the surface moist more of the time, hence shallow roots can feed for a longer time into a drouth period. But the total root system may be less deep and therefore the crop may not feed as effectively on subsoil P and K in a severe drouth. Researchers in Ohio report no loss of fertilizer efficiency in six years of no-plow tillage. McKibben at Dixon Springs in southern Illinois has not observed any problem in three years. Both in Ohio and at Dixon Springs the soils normally do not permit deep rooting. Results on the deep, dark Illinois soils may therefore be different. Farmers who adopt the chisel system probably can mount applicator equipment to place fertilizer to chisel depth. All farmers who shift to no-plow systems may find it advisable to plow once in 5 or 6 years to mix in fertilizer that has concentrated near the surface.

What about a liming program? If anhydrous ammonia, aqua, nitrogen solutions, or dry nitrogen fertilizers are placed 8 to 10 inches deep, zones of soil acidity will develop. Since the neutralizing effect of limestone moves down rather slowly, there is a possibility that soil acidity will become at least a short-term problem below the depth that limestone is mixed in chisel or zero-tillage systems.

Soil and Plant Analyses (Micronutrient) Sampling Completed

A comprehensive three-year survey of the status of major, secondary, and micronutrients in corn and soybeans in 1,706 fields was completed in 1969. County extension advisers supervised the sampling in 74 counties in 1967, 1968, and 1969. The fertilizer industry and county extension councils supplied the money for labor and mileage.

As far as possible one corn and one soybean field were sampled on a known soil within a predetermined 160-acre tract in each township. Soils were sampled at three depths: 0 to 6 inches, 12 to 18 inches, and 24 to 30 inches.

Plants were sampled at two growth stages — corn at 12 to 18 inches and at tasselling, soybeans at 5 to 10 inches and at full height.

Plant samples were analyzed with an emission spectrograph in the Department of Agronomy, University of Illinois, for phosphorus, potassium, calcium, magnesium, manganese, iron, zinc, boron, copper, and sodium. Nitrogen was determined separately. Sulfur was measured on selected samples.

Results from the first two years showed that the plants generally contained adequate amounts of secondary and micronutrients, but a few were marginal in magnesium or zinc in 1967 and in boron, copper, and zinc in 1968.

The county extension advisers were supplied with the proper fertilizer materials to establish field strip trials in 1968 in several counties. There were apparent yield reductions in 7 cases and increases in 4, indicating that the trial technique which involved 5 small strips was not accurate enough to overcome field variability.

Some of the fields that were low in boron and copper were resampled in 1969. If the second sampling confirms the low test found in 1968, field trials will be set up in 1970.

It is evident that carefully conducted research trials will be needed to determine whether a yield increase can be obtained from micronutrients where the plants seem to be somewhat low but there is no visible deficiency. The results from the survey provide an excellent base for planning future trials.

The plant composition data will be valuable reference standards for many years. The soil test data have already been put to good use. The data on available phosphorus in the subsoil helped define the phosphorus-supplying-power regions in Figure 11, page 37.

pH. The pH summary shows that in over one-third of the fields the pH is too low for top profits, in about one-half the pH is just right, and one field in eight is so alkaline that certain micronutrient deficiencies may show up, especially in soybeans (Table 34).

Table 34. — pH of Surface Soils in 1,196 Fields Sampled in 1967 and 1968

pH	Percent of fields	Evaluation
Below 4.6	0.2	Manganese toxicity is common below 5.0.
4.6–5.0	1.5	Needs lime for all crops. Unsuited without liming to grow alflafa or clover. pH 5.6–6.0 is slightly low for corn and soybeans.
5.1–5.5	12.0	
5.6–6.0	21.2	
	(34.9)	
6.1–6.5	31.0	Optimum pH.
6.6–7.0	21.7	
	(52.7)	
7.1–7.5	10.4	Alkaline. Watch for manganese deficiencies in soybeans and oats, and iron deficiencies in Wayne soybeans.
Above 7.5	2.0	
	(12.4)	

Table 35. — P_1 Soil Tests on Surface Soils of 1,706 Fields Sampled in 1967 to 1969

P_1 test	Percent of fields	Evaluation
Below 11.....	3.2	Reasonable goals for corn and soybeans depending somewhat on phosphorus-supplying power of subsoil (Fig. 11, page 37). Phosphorus should be applied for wheat, alfalfa, and clover.
11–20........	12.2	
	15.4	
21–30........	16.9	Very high. Maintenance amounts or less needed.
31–40........	15.2	
41–50........	11.6	
	43.7	
51–100.......	25.1	
101–200......	11.5	Unrealistically high. No application needed.
Above 200....	4.3	
	40.9	

Phosphorus. About one sixth of the fields are definitely low in available phosphorus (Table 35), one-half are near suggested levels or somewhat above, 41 percent are above suggested levels and, of those, 15 percent are unrealistically high. Some of the very high tests may represent only the small area in the field that was sampled rather than the entire field. Extremely high tests may be caused by an old manure pile or burning of brush or corncobs.

Potassium. About 16 percent of the fields are low to very low in potassium for all crops, 18 percent slightly low, and nearly 20 percent are unnecessarily high (Table 36). Some of the highest test results for potassium may have been found on small areas where some residue had been burned.

Table 36. — Potassium Tests on Surface Soils of 1,706 Fields Sampled in 1967 to 1969

K test	Percent of fields	Evaluation
Below 121....	3.4	Very low; soils need broadcast applications for buildup.
121–180......	13.0	
	16.4	
181–240......	18.1	Slightly low.
	18.1	
241–300......	21.9	Optimum to slightly too high. Maintenance applications only needed.
301–400......	24.0	
	45.9	
401–800......	14.4	Unrealistically high. No K needed for at least 2 years where test is 400 or above.
801–1,100....	2.6	
Above 1,100..	3.4	
	19.6	

Research at a few locations shows responses of corn to potassium at soil tests above 241. At present fertilizer prices farmers may choose to aim for a test of 300 rather than 241.

Some interesting relationships showed up among soil tests and plant analyses from the 1968 sampling.

Phosphorus content of both corn and beans at the early sampling date was closely related to soil-test phosphorus, but by midseason the relationships had disappeared in corn. This indicates that the plow layer was no longer the main source of P. The same relationship occurred with potassium.

Zinc increased in corn with increasing soil-test P. This was unexpected, but can readily be explained if it turns out that the highest P tests are on livestock farms where manure would add both P and zinc or where top farmers had applied some micronutrients including zinc.

Zinc and manganese in both corn and soybeans decreased at both sampling stages as pH of the soil increased.

Magnesium decreased in both crops and at both dates when potassium increased either in the soil or in the plant. This suggests that magnesium deficiencies may be caused by heavy K applications on soils that are borderline in magnesium supply.

Within the next year many more relationships will be studied, including effects of subsoil fertility.

Fertility "Quacks" Are Quacking Louder

It seems hard to believe that in this day of better informed farmers the number of letters, calls, and promotional leaflets about completely unproven products is increasing.

The claim is usually that Product X either: replaces fertilizers and costs less; makes nutrients in the soil more available; supplies micronutrients; or is a natural product that doesn't contain strong acids that kill soil bacteria and earthworms.

Research is such a magic word that people are conditioned to expect miraculous new products and thus the door is opened for the fertility quack.

The strongest position that legitimate fertilizer dealers, extension advisers, and agronomists can take is to *challenge these peddlers to produce unbiased research results to support their claims.* Farmer testimonials are no substitute for research! Incidentally, when a legitimate fertilizer company depends heavily upon farmer testimonials in its advertising, then this makes the selling job easier for the quack.

Agronomists can refute the specific claims of the quacks, except when they come up with new claims or fall back on the old cliche, "We don't know why it works, but it does." No one can effectively argue with the farmer who says "It works on *my* farm." Dozens of research trials on the same kind of soil are no match for the simple statement, "It works for me." That is what is so frustrating to dealers, agronomists, and extension advisers and so dangerous to farmers about farmer testimonials.

Extension specialists at the University of Illinois are ready to give unbiased advice when asked either about purchasing new products or accepting a sales agency for them.

Gypsum Promotion Increasing

In spite of repeated statements from agronomists at the University of Illinois that gypsum is not effective under practical conditions, sales promotion appears to be increasing. The number of letters and phone calls from dealers, extension advisers, and farmers grows each year.

Three claims are made for gypsum. First, that it improves soil structure; second, that it is a good source of calcium; third, that it supplies sulfur.

Gypsum improves alkali soils in desert and semi-desert areas of the western United States. Alkali soils contain too much sodium. The calcium in gypsum replaces the sodium which then leaches out of the root zone; the pH declines and the soil structure improves. The high pH soils in central and northern Illinois do not contain large amounts of sodium. They are already high in calcium and magnesium. Adding more calcium can't improve them.

Illinois is now testing gypsum on high-sodium "slick-spot" soils (locally called scalds, hardpans, and deer licks) that occur throughout much of southern and part of western Illinois. Measurable improvement was obtained only where 27.8 tons of gypsum was mixed thoroughly to a depth of three feet. Illinois agronomists tried gypsum on poorly-drained clay soils to learn whether structure and internal drainage could be improved. No improvement was found.

Salt-saturated areas around oil wells are also high in sodium and *may* respond to gypsum, provided the subsoil is permeable enough to allow rainwater to flush the displaced sodium down and out of the root zone. In most cases the subsoil unfortunately is compact and impermeable, and no one has yet found that treatment with gypsum improves this situation.

Gypsum is an effective source of calcium where calcium is deficient as a plant nutrient. But calcium is not deficient in Illinois soils that are raised to the desired pH with limestone. There is no evidence that the calcium: magnesium balance is a problem, hence there is no basis for applying gypsum in place of limestone (see page 36).

Gypsum supplies sulfur, but all Illinois soils appear to be well supplied with sulfur for field crops.

Gypsum is not a substitute for limestone on acid soils. It does not raise the pH.

In summary, there is no known need for gypsum treatment of Illinois soils. The price of products composed mainly of gypsum now being promoted to Illinois farmers is \$150 to \$165 per ton. Anyone who wants gypsum for trial can find plenty of sources within the state where it can be purchased for \$10 to \$20 per ton or in some areas just for the cost of hauling.

SOIL MANAGEMENT AND TILLAGE SYSTEMS

The 1969 Season

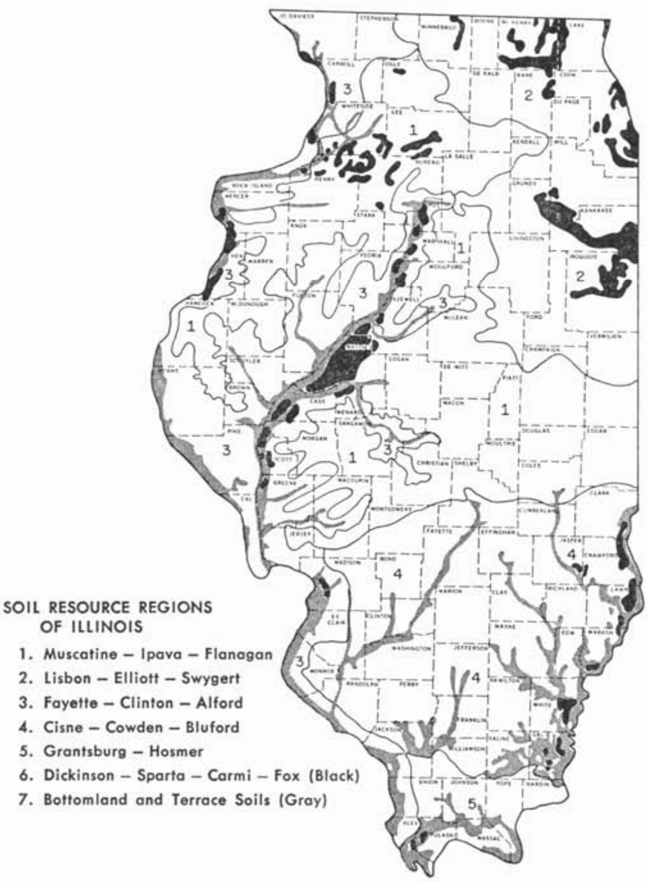
Excess rain and delays in spring field work in many areas in Illinois tested not only the patience of the crop producer but also his soil management system. The wet conditions helped pinpoint areas that need drainage improvement. Intense rain focused attention on the need for more adequate erosion-control methods.

Drainage and erosion control needs are different in different soil regions and even between soils within a soil region. Improvements made in drainage and erosion control (terraces, gully control, and so on) are rather permanent in nature and require careful design and installation. Contact your district conservationist (Soil Conservation Service) for technical assistance.

1969 also provided an opportunity to evaluate the effectiveness of tillage systems. The effect of conservation tillage in reducing soil and water losses was evident in many areas. Weed-control problems and some insect problems were associated with tillage systems in some instances.

Soil Resource Regions

To help pinpoint soil-management problems, seven soil-resource regions have been identified in Illinois (Fig. 13).



Soil resource regions in Illinois. (Fig. 13)

Region 1 includes the Muscatine, Ipava, Flanagan, and associated soils. These soils are generally nearly level to gently sloping; dark colored (high organic matter); and have medium or moderately fine-textured surface layers. Permeability is moderate although some areas with moderately slow permeability occur in the southern and northeast parts of the region. A few areas of light-colored soils (with low organic matter) occur in the region.

Region 2 includes Lisbon, Elliott, Swygert, and associated soils. The region is generally nearly level to gently sloping and has dark-colored soils with medium and moderately fine-textured surface layers. Many soils of the region have a layer of compact glacial till in the lower part of the profile that restricts water movement and root development. Light-colored soils such as Morley, Blount, and Nappanee are extensive in some parts of the region. Erosion and wetness hazards are more severe in Region 2 than in Region 1.

Region 3 includes soils such as Fayette, Clinton, and Alford. Topography is generally sloping to steep. The soils have light-colored, silt loam surface layers. Permeability is moderate to moderately slow. Surface layers have unstable structure and will crust if tilled excessively. Water erosion is a major hazard on soils on steep slopes, which are extensive in the region.

Region 4 is the claypan area of south central and southern Illinois. Cowden, Cisne, Bluford, and associated soils have silt loam surface layers with low organic matter. Permeability is slow to very slow. The topography is nearly level to gently sloping. Many soils on more sloping topography have a fragipan at shallow depths that restricts root development and water movement. Wetness is a serious hazard on nearly level soils, as is erosion on sloping soils. The soils with low organic matter run together over winter if fall plowed. Surface crusting is a problem, especially with excessive tillage.

Region 5 includes Grantsburg, Hosmer, and associated soils. These soils have light-colored, silt loam surface layers and are strongly sloping to steep. A dense fragipan that restricts root and water movement occurs at a shallow depth in many soils of the region. Erosion and crusting are problems that influence tillage decisions in the area.

Region 6 includes sandy soils and soils that have gravel just under the surface, such as Dickinson, Sparta, and Carmi. These soils are drouthy and often subject to severe wind erosion if they are free of vegetation for very long periods of time.

Region 7 includes the major bottomland areas of Illinois and soils of the stream terraces in the southern part of the state. The soils are nearly level to gently sloping, but are quite variable in color, texture, and permeability.

Soil variability within a field often complicates soil-management decisions. Wetness, wind erosion, and flooding are problems.

Important soil differences that influence soil-management decisions occur within each of these seven regions. More detailed information on the soils of a particular region is available from the county extension advisers, the Soil Conservation Service, or the Agronomy Department of the University of Illinois.

Fall Tillage

Get a head start on next year's corn and soybean crops through fall tillage. Chopping stalks, disking, plowing, or chiseling in the fall may help you get off to an early start the following spring. Fall tillage may also present problems if the hazards of wind and water erosion are not considered.

The kind and amount of fall tillage that is needed or desirable depends on the soil, slope, and previous crop, as well as on the seasonal demand for labor and machinery. Of course, weather conditions will have a major role in determining how much tillage is possible before freeze up late this fall or early winter.

The Previous Crop

The previous crop influences the kind and amount of residues that are left after harvest.

Corn residues are the heaviest in terms of tonnage and probably present the greatest problems. Shredding the stalks, or disking followed by fall plowing, or both operations, provide a bare soil surface over winter that may dry earlier in the spring. If the corn stover is not plowed in the fall, leaving the stalks standing without chopping or disking them may provide more wind erosion control than if stalks are shredded. Shredding may protect more of the soil surface against the beating action of rain and thus reduce water erosion. However, the shredded corn residues may mat down and result in wetter soils that are slow to dry out in the spring.

Soybean residues are light in tonnage and present essentially no problem in handling. *Fall plowing soybeans will increase the potential for severe wind erosion. Disking soybean fields in the fall will also create a severe wind-erosion problem.* The surface soil is loose following soybeans and this, combined with the small amount of residues, results in a potentially severe wind-erosion hazard if the soybean field is disked or plowed, or both, in the fall. Fall chiseling following soybeans results in a rougher surface and helps lessen the wind-erosion hazard. Crop yields with spring tillage (plow, disk, chisel, or no-till) have been as good as those with fall plowing in tests in Illinois and Iowa. These tests showed greatly reduced wind-erosion.

Small-grain residues may be plowed in late summer or early fall in preparation for fall seedings of wheat or alfalfa-grass mixtures or for corn or soybeans the following year. Plowing under weeds in the stubble will help reduce weed populations if weeds are plowed before weed seeds mature.

If legume seedings are made in the small grain, more nitrogen will be added by the legume if fall plowing is delayed until late fall (October 15 in northern Illinois, November 15 in southern Illinois). Late-fall plowing of meadow crops will also provide additional time for nitrogen fixation by the legume.

The Soil

Fall plowing decreases tillage problems on poorly drained soils that have high organic matter in the silty clay or silty clay loam surface layers. These soils are usually wet in the spring and will develop poor physical conditions if tilled when too wet. If such soils are fall plowed, large clods will slake down over winter so that spring seedbed preparation is much easier. *However, avoid fall plowing after soybeans on these soils because of the wind-erosion hazard (Regions 1 and 2).*

Dark-colored silt loam soils that are nearly level and have good to fair drainage present fewer tillage problems than the finer textured silty clay loams or silty clay soils (Regions 1 and 2). Fall plowing may be desirable to help spread the labor load or because these soils occur in an intricate pattern with soils that are directly benefited by fall plowing.

Erosion Hazards

Avoid fall plowing where moderate to severe erosion hazards exist, as in the following situations:

1. **Slopes greater than 5 percent.** Slopes of 2 to 4 percent should be plowed as near to contour as is practical (all regions).

2. **Sandy soils.** These are subject to severe wind erosion if left without vegetation (Region 6).

3. **Silt loam soils with low organic matter.** These soils are likely to crust during winter so that spring plowing may be necessary for seedbed preparation (Regions 3, 4, and 5).

4. **Following soybeans.** See the discussion above (Regions 1 and 2).

Fall Disking

Disking corn stalks may aid fall plowing or chiseling. On soils that are too sloping for safe fall plowing, disking in the fall will incorporate part of the residues, loosen the soil, and result in earlier drying in the spring. Earlier seeding of oats or corn may be possible. Wind erosion will be slightly worse if cornstalks are disked in the fall. *Avoid disking in the fall following soybeans because of the danger of wind erosion.*

Fall Chiseling

Fall chiseling is a practice used by many farm operators who have developed tillage systems built around the chisel plow. Fall chiseling of corn stalks leaves part of the residue on the surface for wind and water erosion control. The soil is loosened so it dries earlier in the spring than if the field was untilled over the winter. Fall chiseling is especially important where the chisel plow system is used on dark-colored, poorly drained soils. Delays in spring operations or excessive drying often result if all chiseling is delayed until spring. The rough surface left after chiseling of soybean fields in the fall provides a barrier to soil blowing and reduces the hazard of wind erosion. The rough, chiseled surface is most effective if the chisel operation is carried out perpendicular to the prevailing wind.

Fall-Seeded Cover Crops

Fall seedings of spring oats provide effective control of wind and water erosion if they can be made early enough in the fall for the seeding to be established. The oats should germinate and make sufficient growth for soil protection if seeded by October 1 in the northern one-third of Illinois, by October 15 in the central one-third of Illinois, and by November 1 in the southern one-third of Illinois. Seed directly on fall-plowed fields or on soybean stubble at a rate of 1 to 1½ bushels per acre. The oats will be winter-killed. Seedbeds can be prepared with disk and harrow in the spring. Fall-seeded rye can also be used as a winter cover and may provide some spring pasture. It may be necessary to use a contact herbicide such as paraquat to kill the rye in the spring before planting corn or soybeans.

Summary

Fall tillage can help you get the jump on spring field work if you fit it to your cropping situation and your soil and slope conditions. By using fall tillage where it will benefit you and by avoiding fall tillage where wind and water erosion may be severe, you will have a good foundation on which to develop your overall tillage program.

Tillage Systems

Tillage operations are carried out to prepare a seedbed for planting and a root bed for the development of roots. Tillage is used to loosen or compact the soil, to handle crop residues, to control weeds, and to control or manage water. A variety of tillage systems can be used in crop production. These include conventional, reduced, mulch, and zero-tillage systems. Each has unique advantages and each has limitations.

Table 37. — Tillage Costs per Acre for Alternative Tillage Systems (Corn Following Corn)[a]

Operation	Cost for tillage operations with: Conventional	Plow-plant or wheel-track plant	Cultivator-plant	Chisel-plow	Zero-tillage
Shred stalks..	$ 2.00	$2.00	$ 2.00	$ 2.00	$2.00
Disk........	1.50	....	....	....	....
Plow.......	5.00	5.00	5.00	....	....
Chisel......	....	....	....	4.00[b]	....
Disk........	4.00(twice)	....	....	....	....
Harrow.....	1.00	....	....	1.00	....
Plant[c]......	3.00	3.00	4.00[d]	3.00	3.00
Harrow.....	1.00	....	....	....	....
Hoe........	1.00	....	....	1.00	....
Sweep......	3.00(twice)	1.50	1.50	1.50	....
Spray.......	....	....	....	....	1.50
Total tillage costs......	$21.50	$11.50	$12.50	$12.50	$6.50[e]

[a] Costs in this table are based on data in Illinois Extension Circular 1003.
[b] Many corn producers chisel in fall and again in spring. In these cases chisel charge should be $8 per acre.
[c] Includes applying chemicals with planter attachment.
[d] Cultivate and plant and apply chemicals in one trip over the field.
[e] Cost of chemicals ($5 to $10 per acre) must be added for comparison with other systems.

Conventional Tillage

Conventional tillage uses a moldboard plow followed by liberal use of a disk, harrow, hoe, and cultivator. It is the standard of comparison for other systems.

Advantages:

1. Results in a uniformly fine seedbed for ease of planting.
2. Insecticides and herbicides may be incorporated as needed.
3. Flexible and adaptable to a wide range of soil, crop, and weather conditions.
4. Provides for efficient distribution of labor and machinery.
5. The necessary equipment is readily available on most farms.
6. Results in yields that are as high as or higher than other systems over a wide range of soil and climatic conditions.

Limitations:

1. Highest cost because of the large number of operations (Table 37).
2. Often results in excessive tillage so that soil crusting and compaction may be problems.
3. Results in small aggregates (clods) so that water-intake rate is reduced.
4. Provides few surface depressions for temporary storage of rainfall.
5. Exposes bare, fine, or compact soil that is subject to wind and water erosion.

Reduced-Tillage Systems

Reduced-tillage systems also use the moldboard plow, but with reduction or elimination of secondary tillage with the disk, harrow, hoe, and cultivator. Plow-plant, wheeltrack-plant, and cultivator-plant systems are examples. These systems are designed to provide good contact between seeds and moist soil in the seedling environment (row zone), and a rough, porous area between the rows (water management zone).

Advantages:

1. Reduces costs through elimination of some tillage operations (Table 37).
2. Less chance of forming surface crust.
3. Less compaction.
4. Faster initial intake of water and more water absorption before runoff begins.
5. A rough, porous area between the rows provides temporary storage for rainfall.
6. Reduction in runoff and water erosion.
7. Provides for built-in weed control in rough, porous area between the rows.
8. Cultivator-plant system has flexibility and can be used with fall or spring plowing over a wide range of soil conditions.

Limitations:

1. The rough, porous surface may make planting operations more difficult.
2. Plow-plant and wheeltrack systems require special adaptation to large planters.
3. Plow-plant and wheeltrack systems "bunch" plowing and planting operations into a short period of time. This may be a problem with large acreages or in wet springs.
4. It is difficult to obtain good contact between seed and moist soil in silty clay loam and finer textured soils ("gumbo" soils).
5. Soil is bare and more subject to wind and water erosion than with mulch or zero tillage.

Mulch Tillage

Mulch-tillage systems use chisel, disk, or rotary tillage equipment so that the soil is not turned over as with a moldboard plow. Significant portions of the residues from the previous crop are left on the surface. With the chisel-plow system some secondary tillage with disk or harrow is usually used to prevent an excessively loose seedbed.

Advantages:

1. Lower cost than conventional tillage (Table 37) because there are fewer tillage operations and lower draft requirements.
2. Rough, porous surface (especially with chisel plow and disk) aids rapid water absorption.
3. More water can be absorbed before runoff and erosion begin.
4. Mulch protects soil from raindrop impact and reduces crusting and surface sealing.
5. Mulch slows velocity of runoff and lowers its capacity to carry soil.
6. Mulch protects soil from wind erosion.
7. Fall chiseling or disking of corn stalks will help speed drying of soil in spring so that planting can be done earlier than with moldboard plow systems used in spring.
8. Fall chiseling of soybean fields may reduce wind erosion. *Avoid fall disking following soybeans.*
9. Deep tillage with a chisel plow (deeper than moldboard plow depth) may shatter the plow or traffic pan if it is chiseled when dry.

Limitations:

1. Planters must be equipped to plant in crop residues.
2. Loose, trashy seedbeds may result in uneven emergence. (Use a disk or harrow after chiseling to firm the seedbed.)
3. Soil temperatures may be reduced, resulting in slow early growth of corn in the northern two-thirds of Illinois.
4. Crop residues may interfere with herbicides or cultivation, resulting in a more severe weed problem.
5. Crop residues may harbor corn insect pests.
6. Lime and fertilizer may be concentrated near the surface.

Zero Tillage

Zero-tillage systems consist of planting in an otherwise undisturbed seedbed. Herbicides are used to control weeds and other undesirable vegetation. Zero-tillage has been used for corn following corn, soybeans, small grain, and sod crops (grass or legume). Soybeans and wheat, as well as corn, have been grown in zero- or no-tillage systems.

Advantages:

1. Lower tillage costs since planting and spraying are the only tillage operations (Table 37).
2. Provides the maximum control of wind and water erosion that is possible through tillage alone.
3. Provides a firm seedbed and earlier planting when compared with the spring moldboard plow system, especially in the southern one-third of Illinois.
4. Reduces compaction.
5. Conserves soil moisture.

Limitations:

1. Requires special planting equipment.
2. Results in low soil temperatures and slow early growth of corn in the northern two-thirds of Illinois.
3. Weeds, especially grass weeds, may be a severe problem because of the interference of crop residues with herbicides.

4. Poor stand may limit yields more frequently than with other systems.

5. Residues may harbor insects and rodents.

Strip Tillage

With strip tillage, a strip up to 16 inches wide is tilled in the row area with the area between the rows left untilled. The tillage may be done with a rotary tillage machine, chisels, or a till-planter such as the Buffalo-till planter.

Advantages:

1. Can be adapted to ridge planting to gain additional erosion control and to lessen soil temperature reduction.
2. Other advantages are similar to those listed for mulch and zero tillage.

Limitations:

1. Requires special equipment.
2. Other limitations are similar to those listed for mulch and zero tillage.

Tillage System Combinations

Tillage systems must be designed for a particular situation if they are to be most effective. A system that combines features of one or more of the systems described above may be the best bet to cope with the varying soil and crop-residue situations that exist on most farms. For example, a chisel plow, disk, or zero tillage may be used following soybeans to control wind erosion. If the soils are level and poorly drained, fall plowing with a moldboard plow may be used to minimize early growth problems with corn following corn. Use of the moldboard plow every 3 to 4 years will help provide better distribution of limestone and broadcast phosphorus and potassium applications (see pages 40 and 41).

Careful attention to weed and insect problems may help lessen the limitations of mulch and zero tillage. This is discussed in the next two sections.

Tillage System and Weed-Control Interactions

During 1969 weed problems were severe in many fields. Mulch-tillage and zero-tillage systems seemed to be especially plagued by severe weed problems. The problems were acute where heavy corn residues were left on the surface. Several factors contributed to the problem.

First, the weed seeds are left on or near the surface with mulch and zero-tillage. With conventional tillage, the weed seeds are incorporated so that many are too deep for germination and emergence. They may eventually rot.

Second, the corn residues intercept the herbicides and prevent them from reaching the soil where they are most effective.

Third, the corn residues serve as a mulch and reduce evaporation. The soil at or near the surface has sufficient moisture for weed-seed germination. With conventional tillage the soil at the surface may be dry a higher percentage of the time so that the shallower weed seeds do not have sufficient moisture for germination.

With mulch and zero tillage it is especially important to select herbicides on the basis of the type of vegetation which is or will be present. The following suggestions may help you solve a weed problem with mulch or zero tillage. For rates and use suggestion, see pages 49 to 59.

For existing grass-sod vegetation, perennial grasses, and early emerging annual weeds, apply Paraquat at 1 quart per acre for a quick kill at planting time.

For corn Atrazine plus Ramrod, Atrazine plus Lorox (Lorox may damage corn) or Atrazine alone have been used preemergence for weed control. Atrazine plus oil is used for preemergence application to corn, but is used postemergence for weeds.

For corn following alfalfa Paraquat has not always given effective control of the alfalfa. Banvel has given effective control but should not be used if soybeans have already been planted nearby and have emerged. 2,4-D or Banvel plus 2,4-D is also a possibility for killing legumes. If perennial grass is growing with the alfalfa, Paraquat can be used to control the grass.

For broadleaf weeds that escape the initial treatment in corn 2,4-D postemergence can be effective as a follow-up application.

For grass weeds in corn a directed spray of Dowpon or Lorox may be helpful for postemergence control if there is sufficient height difference between corn and the weeds (see pages 54 and 55).

For soybeans Lorox plus Surfactant WK or Amiben along with Paraquat (1 quart per acre) have looked promising with zero-tillage planting in wheat stubble (double cropping).

The most effective weed control is achieved when the control measures are adapted for each situation. Watch for developing weed problems and be prepared to take corrective action as needed. Postemergence application of herbicides and row cultivation where feasible may mean the difference between success and failure of the tillage system.

Tillage and Insect Control

Some damage from cornborer, common stalk borer, and other insects appeared to be associated with cornstalk residues or grassy weed infestations, or both, in mulch-tilled and zero-tilled corn. In general, control measures with these tillage systems have not differed from those used with conventional tillage. Careful attention to the developing crop may help you recognize a potential insect problem soon enough for effective control. Specific recommendations are available in Illinois Extension Circular 899, "Insecticide Recommendations for Field Crops."

WEED CONTROL GUIDE

This guide for using weed control chemicals is based on research results at the University of Illinois Agricultural Experiment Station, other experiment stations, and the U.S. Department of Agriculture. Although not all herbicides commercially available are mentioned, an attempt has been made to include materials that were tested and showed promise for controlling weeds in Illinois. Consideration was given to the soils, crops, and weed problems of the state.

The field of chemical weed control is still relatively new. The herbicides now available are not perfect. Factors such as rainfall, soil type, and method of application influence herbicide effectiveness. Under certain conditions some herbicides may damage crops to which they are applied. In some cases chemical residues in the soil may damage crops grown later.

When deciding whether to use a herbicide, consider both the risk involved in using the herbicide and the yield losses caused by weeds. If you do not have much of a weed problem and if cultivation and other good cultural practices are adequate for control, do not use herbicides. Much of the risk can be decreased by following these precautions:

- Use herbicides only on those crops for which they are specifically approved and recommended.
- Use no more than recommended amounts. Applying too much herbicide may damage crops, may be unsafe if a crop is to be used for food or feed, and is costly.
- Apply herbicides only at times specified on the label. Observe the recommended intervals between treatment and pasturing or harvesting of crops.
- Wear goggles, rubber gloves, and other protective clothing as suggested by the label. Some individuals are more sensitive than others to certain herbicides.
- Guard against possible injury to nearby susceptible plants. Droplets of 2,4-D, MCPA, 2,4,5-T, and dicamba sprays may drift for several hundred yards. Take care to prevent damage to such susceptible crops as soybeans, grapes, and tomatoes. If it is necessary to spray in the vicinity of such crops, the amine form of 2,4-D is safer to use than the volatile ester form, but even with the amine form, spray may drift to susceptible crops. To reduce the chance of damage, operate sprayers at low pressure with tips that deliver large droplets and high gallonage output. Spray only on a calm day or make sure air is not moving toward susceptible crop plants and ornamentals. Some farm liability insurance policies do not cover crop damage caused by the ester form of 2,4-D.
- Apply herbicides only when all animals and persons not directly involved in the application have been removed. Avoid unnecessary exposure.
- Return unused herbicides to a safe storage place promptly. Store them in original containers, away from unauthorized persons, particularly children.
- Since manufacturers' formulations and labels are sometimes changed and government regulations modified, always refer to the most recent product label.

Where trade names are used in this publication, rates refer to the amount of commercial product. Where common or generic names are used, rates refer to the amount of active ingredient. Unless otherwise stated, rates are given on a broadcast basis. Proportionately less should be used for band applications.

This guide is for your information. The University of Illinois and its agents assume no responsibility for results from using herbicides, whether or not they are used according to the suggestions, recommendations, or directions of the manufacturer or any governmental agency.

Names of Some Herbicides

Trade	Common (generic)
AAtrex	atrazine
Alanap Plus, Whistle, Solo	naptalam plus chlorpropham
Amiben	amiben
Amino triazole, Weedazol	amitrole
Ammate-X	ammonium sulfamate
Atlacide	sodium chlorate plus calcium chloride
Banvel	dicamba
Bladex	SD15418
Brominil, Buctril	bromoxynil
Butoxone, Butyrac, and others	2,4-DB
Chloro IPC	chlorpropham
Cytrol, Amitrol-T	amitrole-T
Dacthal	DCPA
Dowpon	dalapon
Dymid, Enide	diphenamid
Dybar	fenuron
Eptam	EPTC
Knoxweed	EPTC plus 2,4-D
Lasso	alachlor
Londax	propachlor plus linuron
Lorox	linuron
Milogard	propazine
Planavin	nitralin
Primaze	prometryne plus atrazine
Princep	simazine
Ramrod	propachlor
(Several)	dinoseb
(Several)	MCPA
(Several)	sodium chlorate
(Several)	2,4-D
(Several)	2,4,5-T

Sutan . . . . butylate
Tenoran . . . . chloroxuron
Tordon . . . . picloram
Treflan . . . . trifluralin
Urab . . . . fenuron TCA
Urox . . . . monuron TCA
Vernam . . . . vernolate

For clarity, trade names have been used frequently. This is not intended to discriminate against similar products not mentioned by trade names.

Herbicide Application Rates

The performance of some herbicides is influenced considerably by the organic-matter content of soil. You can estimate the organic-matter content of most Illinois soils by using the "Color Chart for Estimating Organic Matter in Mineral Soils in Illinois" (AG-1941), available from your county extension adviser or the Publications Office, College of Agriculture, University of Illinois, Urbana, Illinois 61801. For a more precise determination of organic matter, obtain a laboratory analysis.

After you know the approximate organic-matter content of soil, Table 38 can be used for selecting herbicide rates. Using this guide should help you select rates to provide adequate weed control and minimize herbicide residue.

Corn

For most effective weed control in corn, well in advance of planting plan a program that includes both cultural practices and herbicide applications. If weeds are not serious, cultural practices alone are sometimes adequate. Prepare seedbeds to kill existing weed growth and provide favorable conditions for germination and early growth of corn. Working the soil several times is not essential if weeds can be destroyed during final seedbed preparation. Working the seedbed excessively may intensify the weed problem and contribute to crusting. A relatively high plant population and perhaps narrow rows provide enough shading to discourage weed growth.

Table 38. — Suggested Herbicide Rates for Illinois Soils

Percent organic matter	Pounds of active ingredient per acre on a broadcast basis				
	atrazine	trifluralin	linuron	nitralin	alachlor
1	.8[d]	½	½	¾	1½
2	1.6[d]	⅔	1	1	2
3	2.4	¾	1½	1⅛	2½
4	3.2[a]	1	2	1½[b]	2½
5+	4.0[a, c]	1	3[c]	. . .[b]	2½
	Commercial formulation per acre on a broadcast basis				
	AAtrex 80% wettable powder	Treflan liquid (4 lb./gal.)	Lorox 50% wettable powder	Planavin liquid (4 lb./gal.)	Lasso liquid (4 lb./gal.)
	pounds	*quarts*	*pounds*	*quarts*	*quarts*
1	1[d]	½	1	¾	1½
2	2[d]	⅔	2	1	2
3	3	¾	3	1⅛	2½
4	4[a]	1	4	1½[b]	2½
5+	5[a, c]	1	6[c]	. . .[b]	2½

[a] If you use more than 3 pounds per acre of active atrazine, do not follow with any crop except corn or sorghum the next growing season.
[b] Adapted mainly to soils with less than 4 percent organic matter.
[c] Since results are variable on soils with 5 percent or more organic matter, consider another herbicide or a herbicide combination. Rates indicated for 5 percent or more organic matter are the maximum rates cleared.
[d] On soils with 1 to 2 percent organic matter it may sometimes be preferable to increase the rate of atrazine above that indicated. A slightly higher rate may be desirable where atrazine is incorporated, under unfavorable weather, or for improved control of some weeds.

Early cultivations are very effective for killing weeds. The rotary hoe or harrow works best if you use it after weed seeds have germinated and before or as soon as the weeds appear above the soil surface. Use row cultivators while the weeds are still very small. Set the shovels for shallow cultivation to prevent root pruning and to bring fewer weed seeds to the surface. Throwing soil into the row can help smother weeds in the row. However, if a herbicide has given good control in the row, it is sometimes best not to move soil or weeds from the middles into the row. Where you use a preemergence herbicide, if it is not sufficiently effective, cultivate with the rotary hoe or row cultivator while the weeds are still small enough to control.

Even where herbicides are used, most farmers still use a rotary hoe or harrow for an early cultivation, followed by one or two row cultivations as needed. Some farmers, especially those with narrow rows, high populations, and large acreages, broadcast herbicides and sometimes eliminate cultivation if control is adequate.

Weigh the added expense of broadcasting herbicides against other factors, such as time saved at a critical season. Research indicates that *if weed control is adequate* and the soil is not crusted because of excessive seedbed preparation or other factors, there often is little or no yield increase from cultivation on most Illinois soils. One or two cultivations are, however, often beneficial for controlling certain weed species that are not controlled by the herbicide.

The popularity of preemergence herbicides is partly caused by the need for improved control of weeds, especially annual grasses which became more severe as farmers switched from checking to drilling and hill-dropping corn. Preemergence herbicides also offer a relatively convenient and economical means of providing early weed control and they allow faster cultivation.

You can mix some herbicides with other agricultural chemicals for application. You can apply some to the surface, but must incorporate others into the soil. You can apply some either way. Time of application depends partly on what herbicide you use.

Plan well in advance to select a weed-control program that is most appropriate for your soil, crops, weed problems, farming operations, and personal desires. Be prepared to modify your plans as required during the season.

Preplant Herbicides for Corn

Some herbicides may be applied before planting where you wish to commit yourself to broadcast application.

Preplant applications offer an opportunity to make some herbicide application before the busy planting season. This could be particularly advantageous for custom applicators and for farmers with large acreages. It would allow fewer attachments on the planter. The weather will often dictate the actual time for application, so where preplant applications are planned, you should also have an alternate plan in case preplant applications are not possible.

Preplant-incorporated applications offer an opportunity for applying herbicide, insecticide, and fertilizer at the same time if the chemicals are compatible and if the incorporation gives the proper placement for each chemical.

AAtrex (atrazine) is the major corn herbicide available for preplant application. Although early spring and even fall applications have been tried, research indicates that for corn the closer to planting time you apply AAtrex, the more successful the application is likely to be. Make applications no earlier than two weeks before planting.

Apply AAtrex to the soil surface or incorporate it lightly with a shallow disking or similar operation. The field cultivator has been successfully used for incorporation, but results have not always been quite as good as with a disk. Depth and thoroughness of incorporation will depend on many factors, such as type of equipment, depth of operation and other adjustments, speed, soil texture, and soil physical condition when incorporating.

With so many factors involved, exact specifications for incorporation cannot be given. However, one principle to keep in mind is that the deeper the herbicide is incorporated and the more soil it is mixed with, the more diluted it will be. With excessive incorporation and dilution the effectiveness of the herbicide may be decreased. As a rule of thumb, incorporation devices such as a disk usually move the herbicide only to about half the depth at which the implement is operated.

The major reason for incorporating some herbicides is to reduce loss of herbicide from the soil surface. Since loss of AAtrex is not very rapid, incorporation is not essential. Moving herbicide into soil where there is sufficient moisture for weeds to absorb the chemical may be another advantage for incorporating some herbicides.

AAtrex is very effective for control of many broad-leaved weeds and is often quite satisfactory for control of annual grass weeds. However, under unfavorable conditions it may not adequately control some annual grasses such as giant foxtail, crabgrass, and panicum. Considerable research has been done attempting to find another herbicide that could be combined with AAtrex to improve grass control.

Sutan (butylate) plus atrazine has been successfully used as a preplant-incorporated treatment. This combination has its greatest adaptation to soils above 3 percent organic matter. Sutan can often improve the control of annual grass weeds and the combination gives much better control of broad-leaved weeds than Sutan alone.

For the "tank mix" combination, ½ gallon of Sutan plus 1¼ to 2 pounds of AAtrex 80W per acre broadcast is suggested. Injury to corn from this combination has not been a serious problem thus far, but occasionally injury may occur.

Sutan (butylate) may be used alone as a preplant incorporated treatment at a rate of ⅔ gallon per acre broadcast. Sutan is primarily for control of grass seedlings and may be helpful for control of fall panicum, Johnsongrass from seed, wild cane, and nutsedge. Although it has not been a serious problem thus far, corn may occasionally be injured by Sutan. *It is important to apply Sutan accurately and uniformly to avoid injury.* If you use Sutan alone or in combination with AAtrex, incorporate it immediately after application.

Sutan is cleared for field corn, sweet corn, and silage corn, but not for hybrid corn grown for seed.

Preferred Preemergence Herbicides Applied at Planting

AAtrex (atrazine) is one of the most popular herbicides for corn. It controls both broad-leaved and grass weeds, but is particularly effective on many broadleaves such as smartweed. Corn has very good tolerance to preemergence applications of AAtrex. It is most effective on the light soils that are relatively low in organic matter, but is also effective on soils with more organic matter if you increase the rate. Do not exceed the rates specified on the label. For help in selecting AAtrex rates on the basis of organic-matter content of the soil refer to Table 1.

AAtrex will often persist long enough to give weed control for most of the season. Unless you take proper precautions, enough AAtrex may remain in the soil to damage some crops the following season. Where you apply AAtrex in the spring, do not follow that fall or the next spring with small grains, small seeded legumes, or vegetables. If you use AAtrex 80W at a broadcast rate above 3¾ pounds per acre (or comparable rates in a band) do not plant any crop except corn or sorghum the next growing season.

Soybeans planted where AAtrex was used the previous year may show some effect, especially if you used more than the recommended amount or on ends of fields where some areas received excessive amounts. Applying AAtrex relatively late the previous year and planting soybeans early allows less time for loss of AAtrex residue and increases the possibility of injury to soybeans. Minimizing tillage before planting soybeans also increases the possibility of AAtrex residue affecting soybeans.

You can use AAtrex on most types of corn, including field corn, silage corn, seed-production fields, sweet corn, and popcorn. For use on corn, AAtrex is available from the manufacturer only as a wettable powder for spray application. Mix adequately, provide adequate agitation, and follow other precautions on the label to assure uniform application.

Ramrod (propachlor) has given very good control of annual grass weeds on soils above 3 percent organic matter. On soils with less than 3 percent organic matter, Lasso would be more appropriate than Ramrod. In addition to annual grasses, Ramrod usually controls pigweed and may give some control of lambsquarter.

Most of the commonly grown corn hybrids have good tolerance to Ramrod. It is cleared for field corn, silage corn, hybrid-seed-production fields, and sweet corn.

Ramrod is available as a 65-percent wettable powder and as 20-percent granules. Either formulation of Ramrod can be irritating to skin and eyes. Some individuals are more sensitive than others. Twenty pounds of the granules or 6 pounds of the wettable powder are equivalent to 4 pounds of active ingredient, which is the recommended rate per acre on a broadcast basis. Use proportionately less for band applications.

A good program is to use Ramrod either as a spray or as granules at planting time to control annual grass weeds and follow with an early postemergence application of 2,4-D to control broad-leaved weeds.

Ramrod plus atrazine, each at a reduced rate, has generally given good control of both annual broad-leaved and grass weeds. This combination is best adapted to soils with over 3 percent organic matter. For "tank-mixing" this combination, 4½ pounds of Ramrod 65-percent wettable powder plus 2 pounds of AAtrex 80W wettable powder is the suggested amount for soils with over 3 percent organic matter.

A prepackaged wettable powder combination of Ramrod plus atrazine is available. Use it at a rate of 6 to 8 pounds per acre.

The reduced rate of AAtrex will control many broad-leaved weeds, such as smartweed, but may give marginal control of velvetleaf. The reduced rate of Ramrod in the mixture is adequate for control of most annual grasses. The mixture controls broad-leaved weeds better than Ramrod alone and often controls annual grass weeds better than AAtrex alone. It reduces the AAtrex residue problem, and gives more consistent control on the darker soils or with limited rainfall than AAtrex alone.

Lasso (alachlor) is similar to Ramrod in some respects. Although Lasso has performed well on soils with more than 3 percent organic matter, it is not likely that it will entirely replace Ramrod for corn on these soils in the immediate future. Being less soluble than Ramrod, Lasso may require slightly more moisture initially, but weed control may last a little longer. Lasso performs better than Ramrod on soils with less than 3 percent organic matter. Like Ramrod, Lasso is intended primarily for control of annual grass weeds. Following Lasso with a postemergence application of 2,4-D to control broadleaves gives more complete weed control. Lasso appears promising for control of nutsedge.

Lasso is available as a 4-pound-per-gallon liquid concentrate and as 10-percent granules. Lasso may be used for field corn, hybrid seed corn, and silage corn. At least 12 weeks must elapse following treatment with Lasso before immature corn forage can be harvested or fed to cattle. Refer to Tables 1 and 2 and to the product labels for suggested rates.

Although Lasso is less irritating than Ramrod, the precautions listed on the label should be taken when handling Lasso.

Princep (simazine) usage for corn has been largely replaced by AAtrex. However, Princep, used alone or in combination with AAtrex may give more control of fall panicum than AAtrex alone. Princep may also give some control of wild cane. Being less soluble than AAtrex, Princep may have more residual activity. The major use for Princep would be on soils with less than 3 or 4 percent organic matter.

Bladex (SD 15418) is a new triazine corn herbicide which is similar in some respects to AAtrex. If cleared for corn in 1970, Bladex likely would be introduced as an 80-percent wettable powder primarily in the area with soils relatively low in organic matter.

Research thus far suggests that corn has relatively good tolerance to Bladex. Rates of Bladex may sometimes need to be higher than with AAtrex. Length of control and residual activity may be a little less than with equal rates of AAtrex. Bladex should be applied to the soil surface and not incorporated. Combinations of Bladex with other corn herbicides may offer some potential for the future. Bladex likely will be for preemergence use only.

Less Preferred Preemergence Herbicides Applied at Planting

Because of greater possibility of crop injury or less weed control, the following preemergence herbicides for corn are not considered as satisfactory as those discussed above.

Knoxweed is a combination of Eptam (EPTC) and 2,4-D. It is cleared for use on field corn, sweet corn, and silage corn. Do not use it on seed production fields. Knoxweed has given rather erratic weed control, depending on rainfall and soil moisture. More consistent weed control is likely when rain occurs soon after application. The possibility of corn injury from Knoxweed has not been a serious problem but does exist. Knoxweed has presented no hazard to crops the next season. It is available in both liquid and granular forms. Do not use on peats, mucks, or sands.

2,4-D ester preemergence for corn controls broad-leaved weeds and gives some control of grass weeds. Weed control is rather erratic. There is some chance of injury to the corn. Use only the ester form for preemergence, since the amine form is more subject to leaching. 2,4-D ester is available in both liquid and granular forms.

A combination of **Lorox (linuron) plus atrazine** has been available as a prepackaged, wettable-powder mixture or you can "tank-mix" it on the farm for preemergence use on field corn. Especially on the relatively light-colored soils with low organic matter this combination has often given satisfactory weed control. Using a reduced rate of Lorox in the combination reduces, *but does not eliminate,* the possibility of corn injury. Do not use the combination containing Lorox on sandy soils or injury may result. This combination may give more control of panicum than atrazine alone.

Londax, a combination of Lorox and Ramrod, has clearance for use on field corn for grain or silage. It contains linuron and propachlor in a ratio of 1 to 2 parts respectively of active ingredient. The 45-percent wettable powder formulation contains 15 percent linuron and 30 percent propachlor. The 15-percent granular formulation contains 5 percent linuron and 10 percent propachlor. Rates should be very carefully selected on the basis of soil texture and organic-matter content. Maximum rates are 1½ pounds of linuron plus 3 pounds of propachlor per acre on a broadcast basis. This combination has given relatively good weed control. Control of broad-leaved weeds is better than with Ramrod alone. However, the addition of Lorox *increases the chance of crop injury.* Applications should be made very accurately and uniformly to help avoid crop injury.

Primaze is a combination of atrazine and another triazine compound, prometryne. Although weed control from this combination has been fairly good, *there is increased chance of corn injury with prometryne in the combination.* This combination was introduced commercially in hopes of reducing the atrazine residue problem.

Amiben and **Lorox (linuron)** each have label clearance for preemergence use on corn, but the risk of corn injury is considered too great to recommend their use for this purpose in Illinois.

Postemergence Herbicides for Corn

2,4-D provides one of the most economical and effective treatments for many broad-leaved weeds in corn.

For greatest effectiveness, apply 2,4-D when weeds are small and easiest to kill. You can apply the spray broadcast over the top of the corn and weeds until corn is about 8 inches high. After that height, use drop extensions from the boom down to the nozzles. These "drop nozzles" help keep the 2,4-D off the top of the corn and decrease the possibility of injury. You can direct the nozzles toward the row where most of the weeds will be. However, if you direct the nozzles toward the row, adjust the concentration of the spray so that excessive amounts are not applied to the corn.

Each year some corn is damaged by 2,4-D. It is virtually impossible to eliminate all cases of 2,4-D damage. The chemical usually makes corn brittle for a week or ten days. If struck by a strong wind or by the cultivator, some corn may be broken off. Some stalks may "elbow" or bend near the base. Other symptoms of 2,4-D injury are abnormal brace roots and "onion-leafing," a condition in which the upper leaves remain tightly rolled and may delay tassel emergence.

Spraying 2,4-D during very cool, wet weather when corn plants are under stress, or spraying during very hot, humid weather may increase the possibility of corn injury from 2,4-D.

Some inbreds and some hybrids are more easily injured by 2,4-D than others. It is usually best not to use 2,4-D on inbreds unless you are certain they have a high tolerance. Single crosses may or may not be more sensitive than double crosses, depending on the sensitivity of the inbred parents. Doublecross hybrids and three-way crosses also vary in their sensitivity depending on their genetic makeup.

To help avoid damage to corn, be sure to apply 2,4-D at no more than the recommended rate. The suggested rates per acre for broadcasting are: ⅙ pound of low-volatile ester; ¼ pound of high-volatile ester; or ½ pound of amine.

The ester forms of 2,4-D can volatilize and the vapors move to nearby susceptible plants to cause injury. Since the amines are not so volatile they are less likely to injure nearby desirable plants. However, when spraying either the ester or amine forms, spray particles can drift to nearby susceptible plants.

Here is an easy way to calculate the amount of 2,4-D needed. If using a formulation with 4 pounds of 2,4-D per gallon, each quart will contain 1 pound; each pint ½ pound; and each half-pint ¼ pound. It would take 1 pint of amine formulation to get ½ pound of 2,4-D. A gallon of 2,4-D amine (with 4 pounds of 2,4-D per gallon) would be enough to broadcast 8 acres (4 lb./gal. ÷ ½ lb./A. = 8 acres). A gallon of 2,4-D containing 4 pounds of 2,4-D high-volatile ester would be enough to broadcast 16 acres (4 lb./gal. ÷ ¼ lb./a. = 16 acres).

It is important to spray weeds when they are small and easiest to kill and before they have competed seriously with the crop. However, you can use high-clearance equipment relatively late in the season if you wish, especially for control of late-germinating weeds. Many of the weeds that germinate late are not very competitive with corn, but control would decrease production of weed seeds. Do not apply 2,4-D to corn from tasseling to dough stage.

Amines are salts that are dissolved to prepare liquid formulations and when mixed with water they form clear solutions. Esters of 2,4-D are formulated in oil and when mixed with water they form milky emulsions.

Dacamine and Emulsamine are amine forms of 2,4-D that are formulated in oil and are called oil-soluble amines. Since they are formulated in oil like the esters they are said to have the effectiveness of the esters, but to retain the low-volatile safety features of the amines.

The active ingredient in the various formulations of 2,4-D is still 2,4-D and when you adjust rates appropriately to provide both weed control and crop safety the various formulations are usually similar in their effectiveness.

Banvel (dicamba) is suggested only for emergency use. You can use it as a postemergence spray over the top of field corn until corn is 3 feet high. Rates are ¼ to ½ pint (⅛ to ¼ pound active ingredient) per acre on a broadcast basis. Use proportionately less if placed only over the row.

Banvel is similar to 2,4-D in some respects, but controls smartweed better than does 2,4-D. Corn injury can occur with either Banvel or 2,4-D. *Banvel has often affected soybeans in the vicinity of treated cornfields and has presented a much more serious problem than 2,4-D.* Although soybean yields may not always be reduced, they can be if injury is severe enough. Banvel can also affect other susceptible broad-leaved plants, such as vegetables and ornamentals.

Do not make more than one postemergence application of Banvel per season. You can use Banvel on field corn for grain or silage, but do not graze or harvest for dairy feed before the ensilage stage (milk stage). Use extreme care not to allow Banvel onto desirable plants either by direct application, from contaminated sprayers, or by movement through the air from treated areas.

Because of the limited advantage of Banvel over 2,4-D and the greater risk of injury to other crops in the vicinity, Banvel is usually not recommended. If you anticipate a smartweed problem in corn, AAtrex preemergence or very early postemergence usually gives good control with much less risk of injury to other nearby plants.

AAtrex (atrazine) can be applied as an early postemergence spray to corn up to 3 weeks after planting, but before weed seedlings are more than 1½ inches high. Most annual broad-leaved weeds are more susceptible than grass weeds. The addition of 1 gallon of oil formulated especially for this purpose has generally increased the effectiveness of early postemergence applications of AAtrex. *On the relatively light-colored soils of Illinois, a regular preemergence application of AAtrex will likely remain more popular than postemergence AAtrex* because AAtrex preemergence applications usually give better control with less herbicide on such soils.

On the relatively dark soils of the state there is some interest in the AAtrex-oil treatment. Research and field experience suggest that for those relatively dark soils, 2½ pounds of AAtrex 80W plus 1 gallon of oil may sometimes be just as effective, and sometimes more effective, than a preemergence application of 3¾ pounds of AAtrex 80W. However, a preemergence application is usually preferred.

As with many herbicide applications, the results with AAtrex and oil will be influenced by many factors, and results are not always consistent. For control of annual grasses, it is especially important to apply early when grasses are small.

The early postemergence application with AAtrex and oil may be of particular help where rainfall is less certain, on the darker soils, and where soil conditions are too wet for cultivation.

Although corn has displayed excellent tolerance to AAtrex alone, corn has sometimes shown a general stunting where oil was added. There have been a few cases of fairly severe injury to corn where AAtrex and oil have been used. Weather conditions, stage of growth, rate of growth, genetic differences, and rate of herbicide used with oil seem to be some of the factors involved.

Certain other additives might be used instead of oil to enhance the postemergence activity of AAtrex. One of these is Tronic. Although results with Tronic have not been quite as consistent as with oil, results were often quite similar. An advantage for Tronic would be the need for handling less volume — 1 pint of Tronic per 25 gallons of spray solution.

Directed Postemergence Applications for Corn

Directed sprays are sometimes considered for emergency situations when grass weeds become too tall for control with cultivation. By the time help is sought, the weeds are often too large for directed sprays to be very practical or successful. Since present directed sprays cannot be used on small corn, some other means of control must be used early. Early control with only preemergence herbicides and cultivation is often quite adequate, leaving no need for the directed sprays. Since weeds begin competing with corn quite early, place primary emphasis on early control measures, such as use of preemergence herbicides, rotary hoeing, and timely cultivation.

Directed postemergence may have some potential for controlling some relatively late-germinating grasses, such as fall panicum.

Dowpon (dalapon) may be applied as a directed spray when corn is 8 to 20 inches tall from ground to whorl. Direct Dowpon toward the row using the equivalent of 2 pounds of product on a broadcast basis (⅔ pound in a 14-inch band over 40-inch rows). Dowpon is primarily for control of grass weeds, but 2,4-D can be added for control of broad-leaved weeds. With this treatment, use extreme caution to keep the Dowpon off the corn plant as much as possible to avoid injury. Do not let spray contact more than the lower half of the stalk and do not direct the spray more than 7 inches above the ground. Use "leaf lifters." Other precautions are given on the label. Dowpon does not give a quick kill, but can stunt the grass and reduce formation of weed seeds. Do not use Dowpon on corn grown for seed.

If excessive amounts of Dowpon contact the corn leaves, the chemical can be translocated (moved) inside the plant and may cause stunted and deformed plants, twisted leaves, short ear husks, and abnormal ears. Because of the risk of injury, Dowpon is not usually recommended in Illinois for application to corn.

Lorox (linuron) may be applied as a directed spray after corn is at least 15 inches high (to top of free-standing plant), but before weeds are 8 inches tall (preferably not over 5 inches). This height difference may not occur in some fields and when it does it will usually last for only a few days so the application needs to be very timely. Lorox can control both grass and broad-leaved weeds. Cover the weeds with the spray, but keep it off the corn as much as possible. Corn leaves that are contacted can be killed and injury may be sufficient to affect yields.

Consider this an emergency treatment. Refer to the label for further information and other precautions. A rate of 4 pounds of Lorox 50W on a broadcast basis or proportionately less in a directed band is suggested, but less Lorox may sometimes be adequate, especially for small weeds. Surfactant WK should be added at the rate of 1 pint per 25 gallons of spray mixture.

Soybeans

For soybeans Illinois farmers usually plow the seedbed and use a disk, field cultivator, or similar implement at least once to destroy weed growth and prepare a relatively uniform seedbed for planting. Planting in relatively warm soils helps soybeans begin rapid growth and compete better with weeds. Good weed control during the first three to five weeks is extremely important. If weed control is adequate during that early period, soybeans usually compete quite well with most of the weeds that begin growth later.

Rotary hoeing is very popular for soybeans. It not only helps control early weeds, but it aids emergence if the soil is crusted. To be most effective, use the rotary hoe after weed seeds have germinated, but before the majority of weeds have emerged. Operate the rotary hoe at 8 to 12 miles per hour and weight it enough to stir the ground properly. The soil must be moved sufficiently to kill the tiny weeds.

Following one or two rotary hoeings, use the row cultivator one or two times. Adjust the row cultivator properly and operate it fast enough to move soil into the row to smother small weeds. Avoid excessive ridging which would make harvesting difficult.

It is often said that soybeans in narrow rows provide more shade and compete better with weeds. However, with narrow rows there is more row area where weeds are difficult to control. So a good weed-control program is just as important for narrow-row beans.

There is some interest in "solid drilling" of soybeans in 7- to 10-inch rows. However, you cannot expect present herbicides to control weeds adequately 100 percent of the time. For most situations it is preferable to keep the rows wide enough so you can use cultivation as required.

Use of preemergence herbicides for soybeans has increased rapidly. Over half of the soybean acreage in Illinois is treated with a preemergence herbicide. Whether you should use herbicides for soybeans will depend on the seriousness and nature of your weed problem, as well as your preference for various alternative methods of weed control. Preemergence herbicides are often extremely helpful in obtaining the necessary early control in the row. They can allow a reduction in the number of cultivations, allow faster cultivation, and reduce the amount of ridging needed to smother weeds in the row.

Even though you have used a preemergence herbicide, if it appears doubtful that it will give adequate control, use the rotary hoe while weeds are still small enough to be controlled. Use row cultivation as needed before weeds in the row become too large to be smothered.

When selecting a preemergence herbicide for soybeans, consider the kind of weeds likely to be present. Many of the preemergence herbicides for soybeans are particularly effective for controlling annual grasses. The majority give good control of pigweed, and many will also control lambsquarter. Most do not give good control of annual morningglory, and control of velvetleaf, jimsonweed, and cocklebur is rather erratic.

Many of the preemergence herbicides for soybeans may occasionally cause injury to the soybean plants. Fortunately, soybeans usually have the ability to outgrow modest amounts of early injury, and usually the benefits from weed control provided by the herbicide are much greater than any adverse effects from the herbicides. There may occasionally be exceptions and anyone using herbicides should realize there are some risks involved.

Where you use herbicides for soybeans, it is particularly important to use high-quality seed of disease-resistant varieties. Soybeans that are under stress and do not begin vigorous growth appear to be more subject to herbicide injury. And soybeans that are injured by a herbicide are likely to be more subject to disease. Any one of these factors alone may not be too serious, but several of them acting together could be.

Preplant Herbicides for Soybeans

Treflan (trifluralin) is one of the most effective herbicides for controlling annual grasses such as foxtail. It is also the major soybean herbicide suggested for controlling wild cane and Johnsongrass seedlings. Treflan may also control pigweed and lambsquarter, but does not give good control of most other broad-leaved weeds commonly found in Illinois soybean fields.

Treflan has given satisfactory control of susceptible weeds a high percentage of the time. Soybean injury is possible with Treflan. It may cause tops to be stunted and may cause a reduction in the number of lateral roots in the treated zone. Compared with the advantages of Treflan for controlling annual grasses, the injury from Treflan on a statewide basis is not considered a serious problem. However, in some individual fields where the stand of soybeans is reduced and plants are injured, the problem may be considered significant. Following instructions for rate and method of application is very important in reducing the possibility of injury.

You can apply Treflan just before planting or anytime during 10 weeks before planting. Incorporate it into the soil immediately after application, by using a disk or similar implement to reduce loss from the soil surface. Cross-disk a second time at right angles to the first disking to obtain more uniform distribution. This will help give more uniform weed control and reduce possibility of soybean injury. You can delay the second disking until anytime before planting, and using it for final seedbed preparation just before planting usually improves control.

The disk probably will incorporate the chemical to only about ½ the depth of operation. Disking about 4 inches deep to mix the majority of the chemical into about the top 2 inches usually works best. Having a harrow attached behind the disk is often helpful.

You can use implements other than the disk if they adequately mix the chemical into the top 2 inches. The field cultivator is usually not recommended for incorporating Treflan. Results with the field cultivator sometimes have been acceptable, but are usually not as good as with the disk. The degree of incorporation may vary considerably depending on type of implement, adjustment, speed, soil moisture, soil texture, and other soil physical conditions.

The rate of Treflan is between ½ and 1 quart liquid (½ to 1 pound of active ingredient) per acre on a broadcast basis. Select the rate on the basis of soil type as indicated on the label. After determining the organic-matter content of your soil by estimation or by laboratory analysis you can also use Table 1 as a guide for selecting appropriate rates for most Illinois soils. For most of the light-colored silt loams in Illinois use ½ to ¾ quart per acre; for the dark-colored silty clay loams, and clay loams with over 3 percent organic matter use ¾ to 1 quart per acre.

Treflan is also available in granular form. The granules have not been as popular as the liquid, but appear to be comparable in performance.

In a few cases Treflan residue has carried over to injure corn the following year. In many of these fields the soybean stubble had not been plowed with a moldboard plow. Some areas apparently had excessive applications.

Research also suggests some possibility of Treflan residue affecting small grain. Using no more than recommended rates and making careful applications no later than early June should reduce, but may not eliminate, the possibility of injury to subsequent crops.

Planavin (nitralin) is similar to Treflan in the kinds of weeds controlled. However, research indicates that in Illinois higher rates of Planavin are usually needed to provide about the same control obtained with Treflan.

On some of the light-colored silt loams of the southern part of Illinois, ¾ pound per acre of active ingredient of Planavin (¾ quart of liquid or 1 pound of 75-percent wettable powder) appears to be appropriate. Higher rates are needed as organic matter increases (see Table 1).

Planavin is cleared up to 1½ pounds per acre of active ingredient, but it is not well adapted to the darker soils of the northern part of Illinois. Planavin can be applied within 6 weeks before planting. Incorporate soon after application into the top 1 to 1½ inches of soil with a disk operated shallow or with similar equipment.

Preferred Preemergence Herbicides Applied at Planting Time

Amiben has been one of the most popular herbicides for soybeans. It controls the majority of annual grass and broad-leaved weeds in soybeans most of the season. The major exception is annual morningglory. Control of velvetleaf, jimsonweed, and cocklebur is somewhat erratic. Amiben occasionally injures soybeans, but damage is usually not very severe. When it occurs, injury appears as malformed roots and stunting of the tops.

Amiben is adapted to a wide range of soil types. The manufacturer recommends 1 to 1½ gallons or 20 to 30 pounds of granules (2 to 3 pounds active ingredient) on a broadcast basis per acre or proportionately less for band application. University trials have shown best weed control with 1½ gallons or 30 pounds of granules per acre. If you reduce the rate, weed control may be reduced. Consider the degree of control desired, as well as the cost.

You can make a comparison of 1, 1¼, and 1½ gallons (20, 25, and 30 pounds of granules) per acre on a field and use it as a basis for selecting rates for that field in the future. Granules and liquid perform about equally well. Amiben is easy to handle and is usually applied to the soil surface at planting time.

Ramrod (propachlor) is cleared only for soybeans grown for seed and not for soybeans that will be harvested for food, feed, or edible oil purposes. Most of the comments on page 5 regarding Ramrod for corn apply for soybeans. Lasso is somewhat similar to Ramrod and has broader clearance for soybeans, so Lasso is usually used.

Lasso is intended primarily for control of annual grass weeds, but may also control pigweed and lambsquarter. Lasso also appears promising for control of nutsedge. Soybeans appear to have relatively good tolerance to Lasso although slight distortion of the leaves may appear early.

Lasso is less soluble than Ramrod and may require slightly more moisture initially, but can provide control a little longer than Ramrod. Lasso is not as irritating as Ramrod, but follow precautions listed on the label.

Lasso is available as a liquid with 4 pounds active ingredient per gallon and as 10-percent granules. Lasso has generally performed well on the darker soils and performs better than Ramrod on the lighter soils. Refer to Table 1 for suggested rates on a broadcast basis. Use proportionately less for band applications.

Lorox (linuron) has given relatively good weed control in soybeans, particularly on the light-colored silt loams. However, *the margin of selectivity between dependable weed control and crop damage is rather narrow.* Lorox performance is affected considerably by organic-matter content of the soil. For suggested rates see Table 1.

Selecting rates on the basis of organic matter and making careful applications will reduce, *but may not eliminate, the possibility of crop injury.* Do not use Lorox on sandy soils because of the risk of crop injury.

Chloro IPC (chlorpropham) has not commonly been used in Illinois, except in combination with other herbicides. When tested alone rates of Chloro IPC sufficient to give adequate control of most weeds have sometimes caused soybean injury. However, smartweed is particularly sensitive to Chloro IPC. For controlling smartweed in soybeans, use 3 pounds per acre of Chloro IPC active ingredient on a broadcast basis. You can use this reduced rate of Chloro IPC alone or in combination with some other herbicides that are weak on smartweed.

Less Preferred Preemergence Herbicides Applied at Planting Time

Because of the greater possibility of crop injury or less weed control, the following preemergence herbicides for soybeans are not considered as satisfactory as those previously discussed.

Alanap Plus (naptalam plus chlorpropham) combination has replaced the straight Alanap formerly used in Illinois. Although sometimes satisfactory, weed control from Alanap Plus has been rather erratic. Crop injury can sometimes occur. Under favorable conditions, Alanap Plus can control annual grasses, smartweed, ragweed, velvetleaf, and jimsonweed. Alanap Plus is used at the rate of 1½ gallons of liquid or 40 pounds of granules per acre on a broadcast basis, or proportionately less when banded. This is equivalent to 3 pounds of naptalam and 2 pounds of chlorpropham active ingredient broadcast per acre. This combination has also been available under the names "Whistle" and "Amoco Soybean Herbicide." A similar product will be available under the name of "Solo."

Vernam (vernolate) has given good control of annual grass weeds in Illinois trials, *but some injury to soybeans may occur.* In addition to annual grasses, Vernam controls pigweed, lambsquarter, and may give some control of annual morningglory. Vernam might be considered for serious infestations of wild cane and for control of Johnsongrass seedlings where some soybean injury from the herbicide might be tolerated. Vernam may also be helpful for controlling nutsedge.

It would usually be preferable to incorporate Vernam before planting. However, granules are often banded on the surface at planting. Incorporation of granules is not essential but usually improves control, especially if rainfall is delayed. Rates of active ingredient suggested vary from 2 to 3 pounds per acre depending on soil type, formulation, and method of application.

Postemergence Applications for Soybeans

Tenoran (chloroxuron). Tenoran may be applied at the rate of 2 to 3 pounds of the 50-percent wettable powder in 25 to 40 gallons of water per acre with 1 pint of Adjuvan T surfactant added per 25 gallons of spray solution. This is the broadcast rate, but you can use proportionately less for directed or semi-directed band spraying. Apply from the time trifoliate soybean leaves form and when broad-leaved weeds are less than 1 to 2 inches high.

Some non-phytotoxic oils may be substituted for Adjuvan T, using 1 gallon of oil in 25 gallons of spray solution for a directed or semi-directed spray.

Under favorable conditions Tenoran may give fairly good control of pigweed, lambsquarter, smartweed, jimsonweed, morningglory, and cocklebur. Velvetleaf is more difficult to control and should be not over 1 inch when you treat it. Although intended primarily for control of broad-leaved weeds, Tenoran may give some control of grass if you apply it under favorable conditions when grass weeds are less than ½ inch.

The major interest in Tenoran would be as a possible control for some of the broad-leaved weeds where a preemergence herbicide such as Treflan or Lasso had been used preemergence. Control with Tenoran has been somewhat erratic and soybeans usually show some injury at rates required for weed control. This early season injury to soybeans by Tenoran may not necessarily reduce final yields.

2,4-DB can be considered for emergency situations where cocklebur is quite serious (as in some bottomland areas). 2,4-DB is sold under several trade names including Butoxone SB and Butyrac 175. This herbicide may be broadcast from 10 days before soybeans begin to bloom until midbloom or as a postemergence directed spray when soybeans are 8 to 12 inches tall and cockleburs are 3 inches tall, if this height difference exists.

2,4-DB may also give fairly good control of annual morningglory and giant ragweed. But do not expect good control of most other weeds found in Illinois soybean fields. Soybeans may show early wilting followed by later curving of the stems. Some cracking of stems and some proliferated growth may occur at the base of the plants. Lodging may be increased and if excessive rates are applied or unfavorable conditions exist near time of treatment, yields may be lowered. Carefully follow application rates specified on the label.

Fencerow Control

If the vegetation in fencerows consists primarily of broad-leaved weeds, use 2,4-D at the rate of ½ to 1 pound applied in 10 or more gallons of water per acre. Two miles of fencerow, 4 feet wide equals about an acre.

Make the first application of 2,4-D in May or early June to control early weeds, and make another application in July or early August to control late weeds.

If the fencerow vegetation consists chiefly of woody plants, use a mixture of 2,4-D and 2,4,5-T.

If there are grass weeds such as Johnsongrass or foxtail in the fencerow, you may mix Dowpon (dalapon) with 2,4-D for control of both broad-leaved weeds and grasses. Spray grasses before seed heads form. Use only 2,4-D where the fencerow vegetation consists primarily of broad-leaved weeds and desirable grasses. Use care to avoid injury to nearby desirable plants.

Additional Information

Readers who want additional information on weed control may obtain single copies of the following publications from the Office of Publications, College of Agriculture, University of Illinois, Urbana, Illinois 61801, or from a county extension adviser.

Weeds of the North Central States, Circular 718. ($1.00)

Prevent 2,4-D Injury to Crops and Ornamental Plants. Circular 808.

Controlling Johnsongrass in Illinois. Circular 827.

Controlling Giant Foxtail in Illinois. Circular 828.

Controlling Quackgrass in Illinois. Circular 892.

Calibrating and Maintaining Spray Equipment. Circular 837.

Calibrating and Adjusting Granular Row Applicators. Circular 839.

Controlling Poison Ivy. Circular 850.

Using Preemergence Herbicides. Circular 932.

Color Chart for Estimating Organic Matter in Mineral Soils in Illinois. AG-1941.

Herbicide Application Rates

Table 39 lists the amount of commercial herbicides to apply per acre for liquids or granules, broadcast or banded.

Here is a guide for calculating the amount of herbicide needed for spraying bands for various row spacings:

Row spacing (inches)	Width of band (inches)	Percent of total area covered
20	12	60
20	14	70
24	12	50
28	14	50
30	12	40
30	15	50
36	12	33
38–40	13	33
42	14	33

Formula for other situations: band width ÷ row spacing = percent of area covered.

Example: 12 inches ÷ 36 inches = ⅓ or 33 percent.

By operating your equipment over 1 acre of land you can determine how much spray is used. Do this by starting with a full tank of water and after operating on 1 acre measure the amount of water needed to refill the tank. Multiply the percentage figure from the guide above for your situation times the amount of herbicide recommended for broadcasting. The answer is the amount of herbicide to add with enough water to equal the spray volume you used per acre.

Example: 28-inch rows with 14-inch band; 1 gallon per acre of herbicide recommended if broadcast; 50 percent (from table) × 1 gallon = ½ gallon per acre needed for 14-inch bands on 28-inch rows; if you used 10 gallons per acre of spray, add ½ gallon of herbicide to each 9½ gallons of water to make 10 gallons of spray solution.

When using band treatments the amount of active chemical per row doesn't change with row spacings, but the amount of chemical applied per acre does. Table 40 shows the liquid and granular band rates for 13-inch bands on various row widths.

Table 39. — Amount of Commercial Product To Apply per Acre

Herbicide	12- to 14-inch bands over 40-inch rows		Broadcast	
	Liquid[a]	Granules[b]	Liquid[a]	Granules[b]
Corn				
AAtrex	5/6 to 1¼ lb.	....	2½-3¾ lb.	....
Ramrod	2 lb.	7 lb. (20%)	6 lb.	20 lb.
Lasso	½-⅝ qt.	5-8 lb. (10%)	1½-2½ qt.	15-25 lb.
Knoxweed	1⅓ pt.	7 lb. (14%)	2 qt.	20 lb.
2,4-D ester	1 pt.[c]	3⅓ lb. (20%)	1½ qt.[c]	10 lb.
Eptam	1⅓ pt.	10 lb. (10%)	2 qt.	30 lb.
Sutan	....	....	⅔ gal.	40 lb. (10%)
Soybeans				
Amiben	2 qt.	10 lb. (10%)	1½ gal.	30 lb.
Treflan	⅙-⅓ qt.	3⅓-7 lb. (5%)	½-1 qt.	10-20 lb.
Lasso	½-⅝ qt.	5-8 lb. (10%)	1½-2½ qt.	15-25 lb.
Alanap Plus	2 qt.	14 lb. (12.5%)	1½ gal.	40 lb.
Lorox[d]	⅓-⅔ lb.	....	1-2 lb.	....
Vernam	....	7-10 lb. (10%)	1⅓-2 qt.	20-30 lb.
Planavin[d]	¼-⅓ qt.	....	¾-1 qt.	....

[a] For broadcasting use 10 to 30 gallons of spray solution per acre for liquid formulations. For wettable powders use 20 to 30 gallons of spray per acre.
[b] The amount of granules listed is for material with the indicated amount of active ingredients.
[c] For a 2,4-D formulation containing 4 pounds acid equivalent per gallon.
[d] Amount for light-colored silt loam. See label for rates on other soils.

Table 40. — Liquid and Granular Band Rates for 13-Inch Bands on Various Row Widths

Broadcast rate (gallons per acre)	40-inch rows	38-inch rows	36-inch rows	30-inch rows	20-inch rows
		Liquid (gallons per acre)			
15	4.9	5.1	5.4	6.5	9.8
20	6.5	6.8	7.2	8.7	13.0
25	8.1	8.5	9.0	10.8	16.2
30	9.8	10.3	10.8	13.0	19.5
		Granular (pounds per acre)			
	1	1.1	1.1	1.3	2.0
	2	2.1	2.2	2.7	4.0
	3	3.2	3.3	4.0	6.0
	4	4.2	4.4	5.3	8.0
	5	5.3	5.5	6.7	10.0
	6	6.3	6.7	8.0	12.0
	7	7.4	7.8	9.3	14.0
	8	8.4	8.9	10.7	16.0
	9	9.5	10.0	12.0	18.0
	10	10.5	11.1	13.3	20.0
	11	11.6	12.2	14.7	22.0
	12	12.6	13.3	16.0	24.0
	13	13.7	14.4	17.3	26.0
	14	14.8	15.5	18.7	28.0
	15	15.8	16.7	20.0	30.0
	16	16.9	17.8	21.3	32.0

Control of Major Weed Species With Herbicides

(This chart gives a general comparative rating. Under unfavorable conditions some herbicides rated good or fair may give erratic or poor results. Under very favorable conditions control may be better than indicated. Type of soil is also a very important factor to consider when selecting herbicides. Rate of herbicide used will also influence results. G = good, F = fair or variable, and P = poor.)

Control for Soybeans

	PREEMERGENCE Amiben	Lasso	Treflan	Planavin	Lorox	Alanap Plus	Vernam	POSTEMERGENCE 2,4-DB	Tenoran
Grasses									
Giant foxtail	G	G	G	G	G	F	G	P	P
Green foxtail	G	G	G	G	G	F	G	P	P
Yellow foxtail	G	G	G	G	G	F	G	P	P
Barnyard grass	G	G	G	G	G	F	G	P	P
Crabgrass	G	G	G	G	G	F	G	P	P
Johnsongrass from seed	F	P	G	G	P	P	G	P	P
Wild cane	F	P	G	G	P	P	G	P	P
Yellow nutsedge	P	F	P	P	P	P	F	P	P
Broadleaves									
Pigweed	G	G	G	G	G	G	G	P	G
Lambsquarter	G	F	G	G	G	F	F	P	F
Velvetleaf	F	P	P	P	G	F	F	P	P
Jimsonweed	F	P	P	P	F	F	P	P	F
Cocklebur	F	P	P	P	F	F	P	G	F
Annual morningglory	P	P	F	F	P	F	F	F	F
Ragweed	G	P	P	P	G	G	P	F	F
Smartweed	F	P	P	P	G	G	P	P	F
Soybean tolerance	F	G	F	F	F	F	F	F	F

Control for Corn

	PREEMERGENCE AAtrex	Ramrod	Lasso	Ramrod+atrazine	Sutan+atrazine	Knoxweed	2,4-D ester	Londax	Sutan	Eptam	POSTEMERGENCE 2,4-D	Atrazine and oil
Grasses												
Giant foxtail	F	G	G	G	G	F	F	G	G	G	P	F
Green foxtail	G	G	G	G	G	F	F	G	G	G	P	G
Yellow foxtail	G	G	G	G	G	F	F	G	G	G	P	G
Barnyard grass	G	G	G	G	G	F	F	G	G	G	P	G
Crabgrass	F	G	G	G	G	F	P	G	G	G	P	P
Johnsongrass from seed	P	P	P	P	F	P	P	P	F	G	P	P
Wild cane	P	P	P	P	F	P	P	P	F	G	P	P
Yellow nutsedge	F	F	F	F	F	P	P	P	F	F	P	F
Panicum	F	F	G	F	G	F	P	F	G	G	P	P
Broadleaves												
Pigweed	G	G	G	G	G	G	G	G	G	G	G	G
Lambsquarter	G	F	F	G	G	G	G	G	P	F	G	G
Velvetleaf	F	P	P	F	G	F	F	F	F	F	F	F
Jimsonweed	G	P	P	G	G	F	F	F	P	P	F	G
Cocklebur	G	P	P	G	G	F	G	F	P	P	G	G
Annual morningglory	G	P	P	G	G	F	G	P	P	P	G	G
Ragweed	G	P	P	G	G	F	F	G	P	P	G	G
Smartweed	G	P	P	G	G	F	F	G	P	P	F	G
Corn tolerance	G	G	G	G	F	F	F	F	F	F	F	F

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